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REPORT

OF THE

TESTS OF METALS

AND

OTHER MATERIALS

FOR

INDUSTRIAL PURPOSES

MADE WITH THE

UNITED STATES TESTING MACHINE AT WATERTOWN ARSENAL, MASSACHUSETTS,

DURING

THE YEAR ENDED JUNE 30, 1882.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

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LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

A report of the tests of iron and steel and other materials for industrial purposes, made with the United States testing machine during the fiscal year ended June 30, 1882.

DECEMBER 5, 1882.—Ordered to lie on the table and be printed.

WAR DEPARTMENT,
Washington City, December 4, 1882.

The Secretary of War has the honor to transmit to the United States Senate a letter from the Chief of Ordnance, United States Army, dated November 15, 1882, accompanied with the report of the commanding officer of Watertown Arsenal of the tests of iron and steel, and other materials for industrial purposes, made with the United States testing machine during the fiscal year ended June 30, 1882.

Attention is invited to the recommendations that section 3709 Revised Statutes of the United States be so modified as to exempt the procurement of material for tests from the operation of its requirements, and that authority be given by Congress for the frequent publications of the results of tests in order that information of such great value may be quickly disseminated; also to the recommendation that five hundred additional copies of the accompanying report be ordered printed for the use of the Ordnance Office; all of which recommendations are concurred in by this Department.

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT *pro tempore*,
United States Senate.

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington November 15, 1882.

SIR: I have the honor to submit herewith, for transmission to Congress, as required by law, the report of the commanding officer of Watertown Arsenal of the tests of iron and steel, and other materials for industrial purposes, made with the United States testing machine during the fiscal year ending June 30, 1882.

Attention is invited to the recommendation that the law (section 3709

Revised Statutes) requiring the procurement of supplies by contract after advertisement be so modified as to enable this Department to procure materials for tests in open market. The reasons for this are briefly given in this report. Under this section purchases in open market can only be made when the public exigency requires the immediate delivery. The "public exigency" is therefore one of time only, and it has been so construed by the Attorney-General. I respectfully recommend that section 3709 be so modified as to exempt the procurement of material for tests from the operation of its requirements.

It is urgently recommended that Congress be asked to authorize frequent publications of the results of tests—monthly if possible—that information of such great value may be quickly disseminated. The present report of date August 31, 1882, will hardly issue from the Public Printer before next spring, at the very earliest—many months subsequent to the time when the results were obtained and ready for use.

I have also to recommend that Congress be asked to have printed five hundred additional copies of this report for the use of this office. The calls for it are many and constant, and this Bureau should be in condition to supply a limited number to those most interested.

Very respectfully, your obedient servant,

S. V. BENÉT,
Brig. Gen., Chief of Ordnance.

The Hon. SECRETARY OF WAR.

REPORT

OF

TESTS OF METALS FOR INDUSTRIAL AND OTHER PURPOSES.

WATERTOWN ARSENAL, *August* 31, 1882.

SIR: I have the honor to report that during the fiscal year ended June 30, 1882, the testing machine at this arsenal has been kept busily at work in making tests for private parties and for industrial purposes agreeably to the provisions of the acts of Congress governing its use.

There have been tested during the year 1,587 specimens in all, of which number 855 were for private parties, and 664 were on Government account; the former occupied 97 days, and the latter 208 days. The private parties having work done were 33 in number, 2 of which were from Maine, 17 from Massachusetts, 3 from Rhode Island, 3 from New York, 2 from New Jersey, 4 from Pennsylvania, 1 from Michigan, and 1 from Kansas.

The specimens tested for private parties were by no means so large, the most of them, that they could not be tested on private machines of smaller capacity; many specimens were of quite moderate size, but the parties having tests to make seem to prefer to have the work done on the Government machine, having great confidence in the accuracy of its determinations and the care and faithfulness with which the work is performed.

Since the 9th of March, 1882, the date of your order directing that all money received for making private tests be covered into the Treasury instead of being used to pay the expenses of making such tests, as had formerly been done, there has been turned into the Treasury on this account the sum of $972.84. In addition to this the sum of $2,628.78 was turned into the Treasury from the appropriations of 1881 for making tests for industrial purposes, this being the amount of contracts entered into for materials which were not delivered according to agreement, within the stipulated time; and of the money appropriated for the last fiscal year the sum of $606.76 was covered into the Treasury on account of similar failures of parties to comply with the terms of their contracts. Thus of the moneys appropriated for making tests for industrial purposes $4,208.38 have not been used, but have been returned to the Treasury, mainly because of the want of promptness of contracting parties in furnishing materials for specimens to be tested agreeably to the terms of their contracts. This strict adherence to rules involving the rejection of material simply for the reason that it was not delivered at the time agreed upon, well enough in its way, causes great delays in executing work which is of great importance to the country; and for this and other reasons it is respectfully urged that the system of procuring materials to be tested may be modified so as to allow greater facilities for obtaining the exact kind of material wanted. This subject will be reverted to again before the close of this report.

The tests made during the last year have been mainly on riveted joints, and on the resistance of white and yellow pines to forces of compression in the direction of the fiber, or as used for columns, or posts. This resistance is given in various works on the subject, as it has

been determined by different experimenters. The question to be determined was whether or not the information which we have on this point will serve as a safe and reliable rule for engineers to base their calculations on, in the construction of a bridge or building.

To solve this problem a large quantity of white and yellow pine was purchased in market; the conditions to be fulfilled were that the timber should be sound, free from sap, large and loose knots. It was procured in April, 1881, the white pine mostly from New Hampshire, with some from Michigan, and was stored for more than a year in a dry, well-ventilated store-house, after which it was tested as single and compound columns composed of two, three, and four sticks, bolted together with keys of different thickness interposed, sometimes with different thickness in the same column, giving it a swell at the middle; 191 tests of full-sized columns were made; the most of them were of the same length, 15 feet; the pieces were dressed, and the ends squared with care, so as to give an even bearing; they were first weighed, the rings of growth counted, the grain noted, whether straight or not, and placed in the machine in a horizontal position with the greater depth vertical, so that the weight of the column should have no effect in determining its deflection; the elastic limit, in compound columns, was first determined of the pieces separately, which were afterwards assembled, and the load increased gradually till failure took place.

When only a limited number of tests have been made with carefully selected sticks of small size, there is no trouble experienced in drawing definite conclusions therefrom; but as the tests increase in number and the size of the specimens becomes larger, the difficulty of drawing conclusions increases, and with a large number of tests of specimens of large size, and with the ordinary imperfections of the timber, it is almost impossible to draw any general conclusions applicable to all timbers. It was found that the average load for sticks as large as those used was about one-half of that which is ordinarily given as the ultimate load for these woods; that the weak points are the knots, and in pieces which yield by the crushing of the fibers failure always takes place at the knots; in pieces of greater length the effect of knots is less felt, and it cannot be clearly demonstrated to what extent they influence the resistance of the column; and in very long columns, unless the knots occur near the middle of the length, they seem to have no appreciable effect in determining the direction of flexure. Some sticks were tested a second time after the lapse of a year or more, and in all cases a diminution of strength was observed on the second trial.

A second series of tests was made on yellow pine, each increment of the load being permitted to remain for five minutes and then removed, measuring the set caused thereby. Curves have been plotted showing the effect of this continuance of the load, and the effect becomes more apparent as the ultimate strength of the timber is approached.

In compound columns care should be exercised in selecting the sticks which are to form the column; of course it would be useless to place a poor with a strong stick, but it is best to place the good together and the inferior by themselves. No attention was at first paid to this disposition until experience showed the advantage to be gained by its observance.

To make the effect of knots in the resistance of short posts to compression more apparent, some columns, after having been tested and their resistance determined, were cut up and specimens of shorter lengths taken and tested; the difference in the strength was very marked, as was to be expected. An oak column 168 inches long, which yielded at 4,953 pounds per square inch, showed in a specimen 32 inches long

cut therefrom 8,450 pounds per square inch, and another 7,794 pounds per square inch, which then gave way at a knot. Another post, 164 inches long, failed at 3,432 pounds per square inch, but a piece 32 inches long was cut from it which gave 6,230 pounds per square inch. A yellow-pine post 143 inches long gave a resistance of 4,663 pounds per square inch, but a specimen 32 inches long was taken from it which had a resistance of 6,230 pounds per square inch. Pieces of smaller size could doubtless have been cut from each of these which would have shown still greater strength, as they might have been obtained more free from imperfections of all kinds. Knots of even small size, firm and sound, exercise an injurious effect upon the strength of timber. This was shown in a piece of spruce from which two samples were cut—one having a uniform, straight grain, the other two small knots; the strength of the former was 11 per cent. greater than the latter. A photograph gives some idea of the apparent insignificance of the knots in this case.

When we come to determine the resistance of specimens having knots to forces of compression at right angles to the fibers of the wood, we find the resistance much increased, and this increase should be taken into account when selections for this purpose are possible. The resistance of specimens of a given wood as compared with others of its kind is generally indicated by its specific gravity, but this does not always hold good. In yellow pines, some of those rich in turpentine have a high specific gravity and yet are not the strongest. The rapidity of growth will sometimes give indications of the strength. A rapid growth in oak is apt to be accompanied by an increase of strength, while the reverse is often true in yellow pine.

RIVETED JOINTS.

Testing-machines in general have not been arranged to hold conveniently and rigidly flat plates of considerable width, and consequently there are on record no great number of tests giving the proportions of resistance of such joints to the area of cross-section of metal. With the view of determining the much-needed data on this subject, both as applied to boilers, bridges, and similar structures, I instituted an extended series of experiments, commencing with the tests of ordinary specimens of the material used to determine its tensile strength and to serve as a standard of comparison for all of the succeeding tests. Afterward grooved specimens, 146 in number, were tested. At first the area of cross-section remained constant, the size of the groove varying from $\frac{1}{4}$ inch to $\frac{3}{4}$ inch, and then the area was increased. Of these preparatory tests 214 were made.

Experiments were instituted to determine the amount of friction that is caused by the pressure with which one plate is forced against its neighbor by the riveting. Iron and steel plates $\frac{1}{4}$ and $\frac{3}{8}$ inches were used, held together first with one rivet and afterwards with five rivets; and the shearing strength of the rivets determined. More than 100 tests have been made of single-riveted lap-joints of plates $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ inch, both of iron and steel, and double-riveted lap-joints with $\frac{1}{4}$ and $\frac{3}{8}$ inch plates, and single-riveted lap-joints, with a reinforced welt, with plates of $\frac{3}{8}$ inch, both iron and steel.

A portion of a locomotive boiler which had been in service for twenty-four years was obtained from one of the railroad companies with the view of determining in what way it compared with boilers made at this time. So far as could be detected by examination it had undergone no marked change, but when subjected to stress it showed a grooving of about $\frac{1}{4}$ inch deep. A photograph of the specimen was taken to show

the thickness to which the metal was reduced by this long-continued action.

MISCELLANEOUS TESTS.

Some iron bars which had been previously tested and showed a mean ultimate strength of 52,034 pounds per square inch, were tested again after an entire rest from eight to ten months. The mean ultimate strength after rest was 62,146 pounds per square inch. Such a bar was heated to a cherry-red heat and permitted to cool, when it was tested, and broke at 39,700 pounds per square inch, showing that the increase of strength gained by previous stress was lost by the reheating, and the iron had ceased to be as strong as it originally was.

Some 2-inch round bars of single and double refined iron which could not be tested last year for the want of proper means to hold the bars, have been tested, and show that the ultimate strength of the product of one mill was slightly less for the single refined than the double, and of the other the strength was greater.

Wrought iron I-beams have been tested to give their resistance when used as columns; and some short columns with one pin and one flat end, remnants of columns on hand, have been tested for compression.

With the means at my disposal I am able to give merely the results obtained by the testing machine. I have not the means of working up these results to show more clearly their bearing, and fit them for the practical use of others.

The provision made in the machine for holding flat bars of moderate size, or specimens of plate, are all that can be desired, but the conveniences for testing round bars of all sizes are not so perfect. The specimen, if it be of a ductile material, is diminished in size, and as the holder does not follow up the action of the specimen, the latter is not held so firmly as at first, and finally is liable to slip in the die. The importance of being able to test specimens of round bars of all sizes just as they come from the mills, was deemed so urgent that I proceeded at considerable expense to add to the machine this important and necessary part. It is made throughout of steel, and from the experience thus far had with it there seems to be little doubt of its answering the desired purpose admirably well. As yet I have prepared only a single set of dies for 2-inch bars; others will have to be added as the necessities require and the funds will permit. The cost of this new holder has been $1,309.

Mr. James E. Howard, who has had the immediate charge of the machine and of the tests made thereon, has performed his laborious duties in a manner highly acceptable to myself and the private parties who have had occasion to make use of the machine. His intelligent interest in the work, the care that he takes to insure entire accuracy of results, his quickness to observe all that takes place, and the skill with which he manages the machine, are a sure guarantee for the perfect reliability of the results obtained, and persons who have been present at the tests of their own materials, to see for themselves that every precaution is taken to insure accuracy, have expressed themselves as entirely satisfied in every particular with the manner of conducting the work.

I am indebted to Capt. John Pitman, Ordnance Department, for the chemical analysis of certain specimens of iron and steel, and for the photographs and drawings which serve to illustrate this report. The labor of preparing the latter has been performed by him cheerfully, though it has not been customary to require such work, week after week,

from an officer of his rank; no alternative, however, was left me, for when I asked for authority to procure the services of a draughtsman and computer for this purpose, I was told to call upon my officers to perform those duties. From this it might be argued that a high estimate was not placed on the services of the officers of the Department. I cannot believe that the Government consults its best interests by such assignments of its officers to duty. Captain Pitman can, in my opinion, be better employed than as a draughtsman, accomplished as he is in this particular. I am indebted to Mr. Joseph M. Wilson, C. E., engineer of the bridges and buildings of the Pennsylvania Railroad, and W. S. Thompson, C. E., for suggestions in regard to the tests, the former of riveted joints for bridges, &c., and the latter of wooden columns or posts. I appreciate the interest that these engineers have taken in this work, and have profited by their suggestions.

In my last year's report I proposed to add to this machine the necessary fixtures to enable me to make tests of torsion, and measure the transverse resistance of materials on this machine. Further experience convinces me that in place of changing this machine to adapt it to these several kinds of work it would be better to make new machines for these purposes and retain the present for those tests for which it is so well adapted. The only objection that has come to my knowledge in relation to the tests made by the Government on this machine is the expense attending them. This has been urged only by those who have had very long specimens to test; and in order to do this work extensive changes had to be made in the machine to prepare it for the extraordinary demand made upon it. It requires a half day and the services of three additional men to remove the holders from their normal position so as to take in these long specimens; and when, as it often occurs, they have considerable ductility, the time required to follow up a stretch of 40 inches or more, as has been necessary in some cases, and to rupture the specimen, necessarily makes the expense proportionately great. If, as in other machines, only specimens of nearly one size were tested, this expense of shifting from kinds of work widely dissimilar would not be required; but just in proportion as the machine is made to do a greater variety of work, so will the cost of doing this work be increased from the necessity of making greater changes in the machine to adapt it thereto. In the selection by a certain party of a machine on which to do some extensive work of testing, outside considerations made it desirable that another machine than that of the Government should be chosen. Examination of both machines was made, with the view of determining which should be finally chosen; and the result of the investigation led to the selection of the Government machine, as the choice of any other would involve too great a sacrifice of time and convenience to render it admissible. The wisdom of the choice has been made apparent by both the quantity of work as well as its quality; as many as 80 tests having been made in one day, when the specimens varied only slightly and many measurements were not required.

It almost always happens that a combination machine is made such at the sacrifice of some one or more important feature, and to attempt to engraft on the testing machine now on hand, which will have work enough to keep it busy for years to come, the means of making transverse and torsional tests, will result in providing means of making transverse and torsional tests inadequate to the wants of the country, and will further complicate the machine so as to increase the labor of adapting it to these various kinds of work and thereby proportionally add to

the cost. I would therefore respectfully recommend that, instead of changing this machine to adapt it to perform any new service, it be retained for the uses for which it is at present prepared, and that new machines be built for testing transversely and by torsion. We shall then have the most complete means of performing economically the several tests to which it is desirable to subject materials according to the use or purpose for which they are intended, and this course will in the end prove not only the most convenient but also the most economical and satisfactory.

There are one or two points in regard to which it is highly desirable that there should be some special legislation to render it possible to carry on this work to the best advantage. And first, in regard to the procurement of materials. The law requiring the contract for supplies furnished to be given to the lowest bidder renders it impossible at times to procure just the kind of materials which it is desirable to test. I have just been testing the white and yellow pines as they are found in our markets. Of these woods we know next to nothing, where they grew, when they were cut, of what varieties they are, what kind of soil furnished them, &c. It is highly important that we should make tests of timber in large pieces cut from trees, the complete history of which we can be perfectly sure of. This is not possible without some change in the law directing how purchases shall be made.

So, again, it is desirable that we should test specimens of iron and steel made from certain ores, the history of which and the product in all of its details we shall have full and complete knowledge of. How can we have this when we must purchase of the lowest bidder and take his word only that we shall have what we require?

Again, it is desirable that we shall have the means of printing the results of the tests without waiting some two years to have it done as at present; and we also much need the means of disseminating this information where it is most wanted and most highly appreciated. There is information in this report of great interest and value to certain industries which will be kept in ignorance of it for two years or more after the tests were made, when the parties could, by a different system of publication, not practicable without new legislation, have been in possession of the main facts almost immediately after the facts were determined.

Applications are constantly made to me for copies of the reports of the tests which have been already made. It would seem to be a very proper arrangement to place a given number of those reports at the disposal of the officer having charge of the making of the tests, to be disposed of on the payment of a fixed price, to enable those who have an interest in knowing about the tests to procure at a moderate expense the detailed report of them.

I would again recommend that specimens which have been tested may be sold, and the proceeds used in procuring other materials for similar purposes, a report, of course, of all such sales to be made to Congress. The money appropriated for the testing of materials for industrial purposes, so far as it has been spent, it is believed has been expended judiciously, economically, and for the purposes for which it was appropriated. The results obtained will be appreciated most by those who know most of the wants that are thereby filled, who are most conversant with the subject considered. A larger sum of money than has heretofore been granted by any annual appropriation can be expended to great advantage to the country at large in carrying on these tests. This is a matter in which all are more or less intimately con-

cerned, as all are interested in the safety of our bridges, public buildings, locomotive and steamboat boilers, &c., which may be made by the aid of such information as can only be obtained from such tests as are here referred to, both safer and more reliable, and at the same time less expensive than at present.

Money is freely and wisely given for the dissemination of useful practical knowledge in regard to any of the various branches of agriculture, but the people are as much interested in the development of our immense mineral resources and the improvement of our manufactured productions as in those of the soil. Valuable information furnished in reference to the former will repay as surely and promptly the cost attending its determination and dissemination as the latter. An enlightened policy demands liberality in expenditures for each of these purposes, for the public need is as intimately connected with the sure, steady, and rapid development of the one as the other.

Very respectfully, your obedient servant,

T. T. S. LAIDLEY,
Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE.

REMARKS ON RIVETED JOINTS.

This series of tests comprises the tensile tests of joints with plates having a nominal thickness of $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{5}{8}''$, and $\frac{3}{4}''$ of wrought iron and open hearth steel.

The tensile test of the material itself for each thickness of plate.

In $\frac{1}{4}''$ plates was determined the strength of grooved specimens, the resistance to shearing out at rivet holes, and shearing parallel to the grain of the metal. Experiments upon the friction of rivets are given. The wrought-iron plate was furnished by one maker out of one quality of stock.

The steel plates were supplied from one heat cast in ingots of the same size, the thin plates differing from the thicker plates only in the amount of reduction given the metal by the rolls.

All joints have machine-driven rivets unless otherwise stated in the detailed notes. "Burden's best" iron rivets used; steel rivets made of mild steel of about the same quality as employed for boiler plates.

The joint plates have planed edges; except where calked the metal was first planed and then chipped to a beveled edge. Elongations were measured within a gauged length of 10″ including and symmetrical with the center line of the joint. An exception to the above location of the gauged length is found with the $\frac{1}{4}''$ iron butt joints, where the 10″ gauged length began at a point on the center line of the welt and included only one row of rivets.

The recorded elongations show the slip of the joint plus the elongation of the plates.

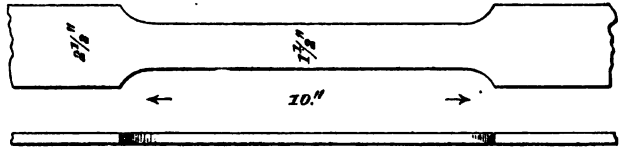
The modulus of elasticity of the metal was found: Iron plate, 31,970,000 pounds; steel plate, 28,570,000 pounds.

The space between the testing-machine jaws was kept at 24″. Joints were adjusted in the jaws to compensate for the offset of the lap. As loads were applied observations were made to determine the amount of distortion indicated by the opening of the joint at the calked edge.

In the tabulated results the manner of fracture is shown by sketches of the joints, and is further indicated by underscored figures in columns headed: Maximum strains on joint, pounds per square inch.

TENSILE TESTS OF WROUGHT-IRON PLATE.

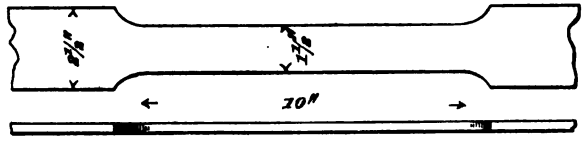
Material used in riveted joint tests.



Number of test.	Nominal thickness.	Direction of grain.	Actual dimensions.		Sectional area.	Elastic limit.		Ultimate strength.		Elongation in 10 inches.	Uniform elongation.	Area at fracture.	Contraction of area.	Appearance of fracture.	Remarks.
			Thickness.	Width.		Actual pounds.	Pounds per square inch.	Actual pounds.	Pounds per square inch.						
	In.		*Inch.*	*Inches.*	*Sq. in.*					*Per ct.*	*Per ct.*	*Inches. Sq.in.*	*Per ct.*		
440	¼	Lengthwise	.257	1.515	.389	14,150	36,370	18,810	48,350	17.0	16	.21 x 1.43=.300	22.9	Fibrous lamellar.	Hammered cold before testing with 6-pound hammer, stretching metal ".16 in 10"=1.6 per cent. Rapid stretching began at 44,920 pounds per square inch.
441	¼	.. do	.238	1.514	.360	12,980	36,050	17,100	47,500	16.8	16	.20 x 1.43=.286	20.6	....do	
442	¼	....do	.260	1.516	.394	Not obtained.		20,280	51,470	8.4	7	.20 x 1.48=.296	24.9	....do	
443	¼	Crosswise ..	.265	1.500	.397	10,200	25,700	15,150	38,160	4.5	4	.25 x 1.46=.365	8.1	....do	
444	¼	do	.266	1.500	.399	9,900	24,810	15,100	37,840	4.0	3	.25 x 1.47=.367	8.1	....do	
77	⅜	Lengthwise	.375	1.494	.560	18,300	32,679	26,650	47,590	13.6	12	.32 x 1.42=.454	18.9	Fibrous, marked lamination.	Hammered cold before testing, stretching metal ".15 in 10".
78	⅜	....do	.377	1.495	.564	17,200	30,496	26,380	46,773	10.8	10	.34 x 1.43=.486	13.8	... do	
79	⅜	....do	.376	1.496	.562	20,800	37,010	27,250	48,488	5.0	2	.34 x 1.47=.500	11.0	.. do	
255	½	Lengthwise	.515	1.500	.773	19,400	25,100	33,550	43,400	11.4	10	.44 x 1.41=.620	19.8	Fibrous	Hammered cold before testing, stretching metal ".19 in 10".
256	½	....do	.511	1.503	.768	19,800	25,789	35,200	45,830	13.8	13	.45 x 1.41=.635	17.3	....do	
257	½	....do	.501	1.502	.752	Not well defined		38,800	51,600	4.5	Irregular.	.44 x 1.49=.656	12.8	....do	
310	⅝	Lengthwise	.621	1.496	.929	24,500	26,370	40,900	44,030	10.3	10	.55 x 1.44=.792	14.8	Fibrous dull	Hammered cold before testing, stretching metal ".15 in 10".
311	⅝	....do	.621	1.505	.935	23,800	25,450	42,300	45,240	12.4	12	.55 x 1.43=.787	15.8	....do	
312	⅝	....do	.627	1.497	.939	Not well defined		44,700	47,600	4.9	.....	.55 x 1.50= 825	12.1	.. do	
313	¾	Lengthwise	.696	1.505	1.047	29,200	27,890	48,950	46,750	12.8	11	.61 x 1.42=.866	17.3	Fibrous dull	Hammered cold before testing, stretching metal ".15 in 10".
314	¾	....do	.694	1.495	1.038	27,450	26,440	48,200	46,430	13.8	11	.61 x 1.39=.848	18.3	... do	
315	¾	....do	.696	1.492	1.038	Not well defined		53,250	51,300	7.0	.....	.59 x 1.49=.880	15.2	... do	

TENSILE TESTS OF O. H. STEEL PLATE.

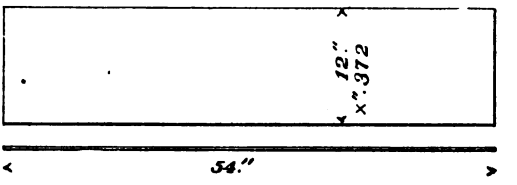
Material used in riveted joint tests.



Number of test.	Nominal thickness.	Actual dimensions.		Sectional area.	Elastic limit.		Ultimate strength.		Elongation in 10 inches.	Uniform elongation.	Area at fracture.	Contraction of area.	Appearance of fracture.	Remarks.
		Thickness.	Width.		Actual pounds.	Pounds per square inch.	Actual pounds.	Pounds per square inch.						
	In.	*Inch.*	*Inches.*	*Sq. in.*					*Perct.*	*Perct.*	*Inches. Sq. in.*	*Perct.*		
397		.247	1.515	.374	14,700	39,440	20,940	56,000	26.7	20	.13 x 1.24=.161	57	Silky	Hammered cold before testing, stretching metal ".15 in 10".
398		.244	1.513	.369	15,600	42,280	20,490	55,530	24.2	20	.14 x 1.16=.162	56.1	....do	
399		.250	1.51	.378	15,000	39,680	22,060	58,360	19.2	13	.11 x 1.28=.141	62.7	Fine silky	Hardened specimen heated cherry-red and plunged into cold water.
400		.248	1.512	.375	17,800	47,470	27,900	74,400	13.4	8	.12 x 1.31=.157	58.1	....do	
72		.375	1.502	.563	19,500	34,636	29,300	52.042	28 6	24	.20 x 1.04=.208	63.1	Fine silky	Hammered cold before testing, stretching metal ".11 in 10".
73		.377	1.492	.562	18,200	32,384	29,400	52,313	27.8	21	.21 x 1.03=.216	61.5	....do	
74		.375	1.500	.563	17,800	31,616	30,250	53,730	26.6	18	.21 x 1.08=.227	59.7	...do	
75		.373	1.498	.559	17,800	31,810	30,200	54,025	27.1	21	.20 x 1.04=.208	62 8	....do	
76		.372	12.000	4.46	141,000	31,610	245,000	54,930	.....	17	.19 x 10.06=.191	57.2	Silky	
252		.500	1.490	.745	23,200	31,140	42,200	56,640	29.2	24	.30 x 1.06=.318	57.3	Silky	Hammered cold before testing, stretching metal ".16 in 10".
253		.501	1.499	.751	23,500	31,290	43,490	57,790	26.1	20	.33 x 1.09=.360	52.1	....do	
254		.496	1.500	.744	33,500	45,030	43,180	58,040	23.0	19	.29 x 1.15=.333	55.2	....do	
304		.621	1.504	.934	29,980	32,100	49,100	52,570	29.0	24	.35 x 1.00=.350	62.5	Silky	Hammered cold before testing, stretching metal ".15 in 10".
305		.621	1.495	.928	31,300	33,730	48,550	52,320	28.2	21	.35 x 1.00=.350	62.3	.. do	
306		.621	1.500	.932	Not well defined.		49,600	53,220	27.1	18	.33 x 1.07=.353	62.1	....do	
307		.731	1.500	1.097	33,850	30,860	56,400	51,410	29.5	22	.39 x .90=.374	65.9	Silky	Hammered cold before testing, stretching metal ".15 in 10".
308		.734	1.502	1.102	33,550	30,440	56,950	51,680	28.7	22	.41 x .96=.394	64.3	....do	
309		.730	1.500	1.095	Not well defined.		57,250	52,280	28.6	25	.37 x 1.04=.385	64 8	....do	

No. 76.

TENSILE TEST, $\frac{3}{8}$" STEEL PLATE.



Sheet stamped T. S., 60,000 pounds.
Sectional area, 4.46 square inches.
Gauged length, 20".
Free length of specimen between holders, 32".

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
4,460	1,000	0.		
22,300	5,000	.0025		
44,600	10,000	.0060		
	1,000		0.	
66,900	15,000	.0095		
89,200	20,000	.0130		
	1,000		0.	
111,500	25,000	.0165		
	1,000		0.	
118,000		.0178		
123,000		.0182		
125,000		.0188		
127,000		.0190		
129,000		.0191		
131,000		.0195		
133,800	30,000	.0200		
	1,000		0.	
135,000		.0202		
137,000		.0205		
139,000		.0208		
141,000	31,610	.0212		Elastic limit.
143,000		.0255		
145,000		.0480		
147,180	33,000	.0800		
151,640	34,000	.14		
156,100	35,000	.38		
178,400	40,000	.60		
200,700	45,000	.94		
223,000	50,000	1.58		
245,000	54,930			Ultimate strength.
0	0	3.70=		18.5 per cent.

Elongation of inch sections, ".14, ".14, ".14, ".14, ".15, ".15, ".16, ".16, ".16, ".16, ".16, ".16, ".17, ".17, ".17, ".17, ".17, ".17, ".18, ".19, ".20, ".21, ".23, ".25, ".29, ".34, ".44, ".57, ".96, ".38.

Minimum width at fracture, 10".06.

Average thickness at fracture, ".19.

Area at fracture, 1.91 square inches. Contraction of area, 57.2 %. Silky fracture. The specimen varied in thickness; the elastic limit was passed in the minimum section first. Fracture occurred at the smaller end, and the elongations show the greatest stretch at this end.

When the "Cooper lines" were first developed some appeared at right angles to the axis of the specimen; others followed in diagonal lines from each edge, intersecting each other.

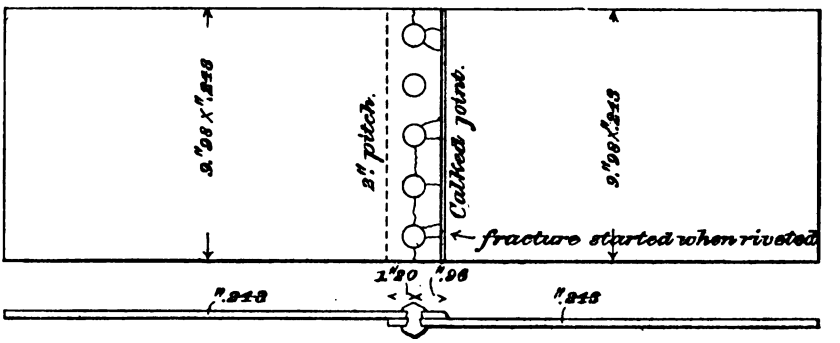
The diagonal lines make an angle of 56° 20′ with the axis of the specimen.

The direction of fracture was diagonally across plate at an angle of 67° 10′ with the axis of the specimen.

When the fractured ends are brought together an opening at the middle remains about ″.23 wide.

SINGLE-RIVETED LAP JOINTS, ¼″ IRON PLATE.

No. 35.—¼″ IRON PLATE. JOINT A.



⅝″ iron rivets, "Burden's best."

Punched holes: Punch, ″.695 diameter; die, ″.752 diameter.

	Square inches.
Gross sectional area of plate	2.425
Net sectional area of plate	1.55
Bearing surface of rivets	.88
Shearing area of rivets (″.70 diameter)	1.92

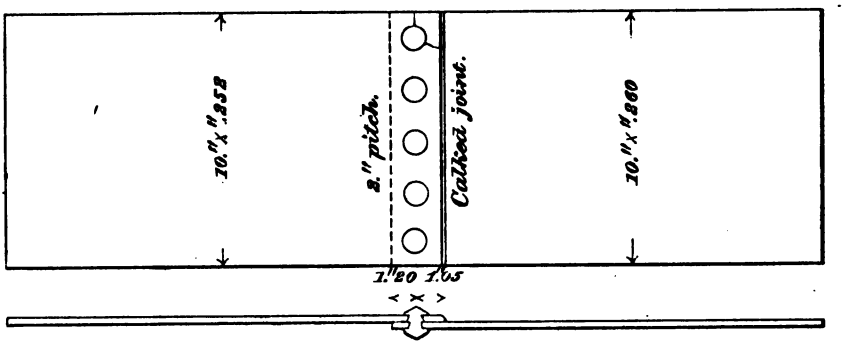
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
8,000	.0009		
10,000	.0012		
15,000	.0028		
20,000	.0040		
25,000	.0059		
30,000	.0080		
35,000	.0108		Joint opened about ″.01, or less.
5,000		.0030	Rivet heads scale.
40,000	.0145		
42,000	.0162		
44,000	.0188		
46,000	.0212		
48,000	.0240		
50,000	.0270		Joint opened barely ″.02.
52,000	.0298		
54,000	.0345		
56,000	.0480		
58,000	.0556		
60,000	.0635		
62,000	.0735		
67,000			Ultimate strength.

Failure occurred by tearing out upper plate at four rivets, as shown by the sketch, and by shearing one rivet, second from outside. The fracture first in sight appeared at the end of the plate at the calked side of the joint. Fractures also appeared at the end of the lap opposite the three middle rivets. In the under plate no fracture apparent at the holes. The sheared rivet had fracture started under the head. Another rivet was slightly fractured in the same manner.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	27,630
Tensile strain on net section of plate	43,230
Compressive strain on bearing surface of rivets	76,140
Shearing strain on rivets	34,900

No. 36.—¼″ IRON PLATE. JOINT A . .



⅝″ iron rivets, " Burden's best."
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.52
Net sectional area of plate	1.63
Bearing surface of rivets	.895
Shearing area of rivets (".70 diameter)	1.92

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0009		
15,000	.0018		
20,000	.0028		
25,000	.0040		
30,000	.0058		
35,000	.0078		
5,000		.0018	
38,000	.0088		
40,000	.0103		
42,000	.0117		
44,000	.0130		
46,000	.0148		
48,000	.0163		Joint open at calking about ".01.
50,000	.0198		
52,000	.0253		
54,000	.0308		
56,000	.0378		
58,000	.0458		
60,000	.0537		Joint open about ".04 to ".05.
62,000	.0613		
64,000	.0708		
66,000	.0800		
68,000	.0920		
74,200			Ultimate strength.

Joint failed by shearing four rivets, and tore out upper plate at one end rivet.

Fractures started at end of lap in each plate and opposite each rivet but one.

All the sheared rivets had fractures started under the heads.

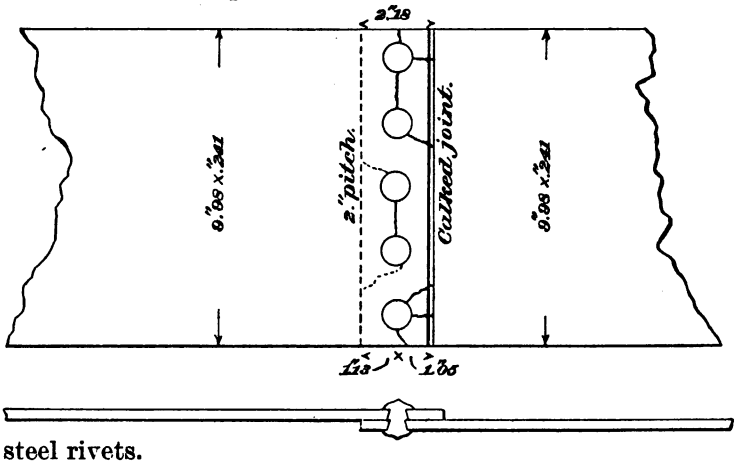
Elongation of holes from ".04 to ".08.

Holes with the die-side in, stretching the most.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	29,444
Tensile strain on net section of plate	45,520
Compressive strain on bearing surface of rivets	82,910
Shearing strain on rivets	38,640

No. 41.—¼″ Iron Plate. Joint A A .



⅝″ steel rivets.

Punched holes: Punch, ″.69 diameter; die, ″.75 diameter.

	Square inch.
Gross sectional area of plate	2.41
Net sectional area of plate	1.54
Bearing surface of rivets	0.868
Shearing area of rivets (″.70 diameter)	1.92

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inches.*	*Inches.*	
5,000	.0		
10,000	.0012		
15,000	.0028		
20,000	.0041		
25,000	.0062		
30,000	.0090		
35,000	.0120		
5,000		.0040	
38,000	.0149		
40,000	.0161		Perceptible starting of the joint.
42,000	.0180		Joint open about ″.00½.
44,000	.0210		
46,000	.0238		Joint open ″.01.
48,000	.0260		Joint open ″.02.
50,000	.0289		
52,000	.0329		
54,000	.0356		Joint open about ″.03½.
56,000	.0400		
58,000	.0438		
60,000	.0480		Joint open ″.05.
62,000	.0528		
64,000	.0589		
66,000	.0650		
68,000	.0790		
70,000	.0860		
72,000	.0970		
74,000	.1080		
75,800	.1240		
76,100			Ultimate strength.

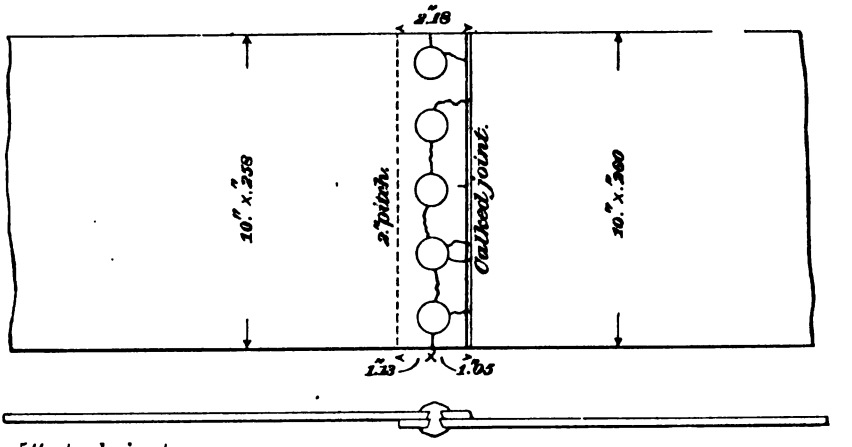
Fractures appeared first at end of upper plate opposite the outside rivets, shown at A . on the sketch.

The upper plate tore out behind three rivets; the lower plate at two rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	31,580
Tensile strain on net section of plate	49,420
Compressive strain on bearing surface of rivets	87,670
Shearing strain on rivets	39,640

No. 42.—¼″ Iron Plate. Joint A A . .



⅝″ steel rivets.

Punched holes: Punch, ″.69 diameter; die, ″.75 diameter.

	Square inches.
Gross sectional area of upper plate	2.58
Net sectional area of upper plate	1.65
Bearing surface of rivets	.929
Shearing area of rivets (″.70 diameter)	1.92

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
15,000	.0020		
20,000	.0030		
25,000	.0052		
30,000	.0072		
35,000	.0102		
5,000		.0045	
38,000	.0128		
40,000	.0140		Joint started perceptibly.
42,000	.0159		
44,000	.0180		
46,000	.0210		
48,000	.0238		
50,000	.0260		Joint opened ″.01.
52,000	.0290		
54,000	.0335		Joint opened ″.02.
56,000	.0370		Joint opened ″.03.
58,000	.0420		
60,000	.0468		
62,000	.0530		Joint open about ″.04.
64,000	.0600		Joint open about ″.05.
66,000	.0698		Joint open about ″.06.
68,000	.0780		
70,000	.0870		
74,000	.1085		
76,000	.1215		
77,980	.1410		Ultimate strength.

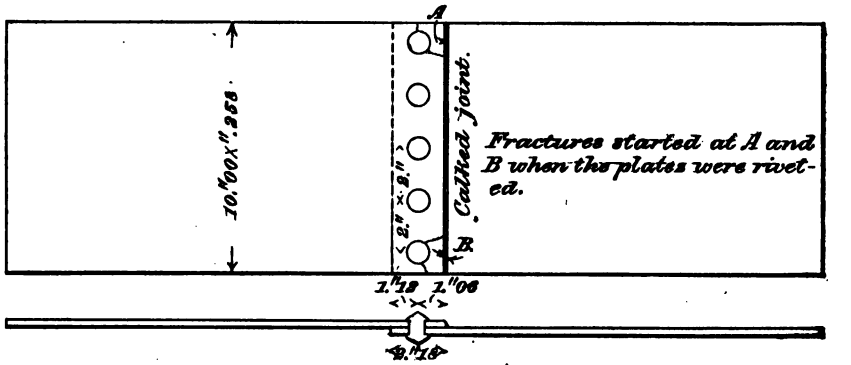
Joint failed by tearing apart upper plate similar to A A., fractures first appearing at end of upper opposite the outside rivets.

The under plate has a slight fracture at end of lap opposite the second rivet.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	30,220
Tensile strain on net section of upper plate	47,260
Compressive strain on bearing surface of rivets	83,940
Shearing strain on rivets	40,610

No. 37.—¼″ Iron Plate. Joint C.



⅝″ iron rivets, "Burden's best."

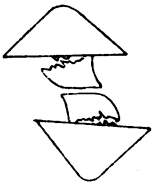
Drilled holes, ".69 diameter.

	Square inches.
Gross sectional area, upper plate	2.58
Gross sectional area, lower plate	2.44
Net sectional area, upper plate	1.69
Bearing surface of rivets, upper plate	.89
Shearing area of rivets (".69 diameter)	1.87

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0015		
15,000	.0027		
20,000	.0042		
25,000	.0059		
30,000	.0082		
35,000	.0112		
5,000		.0036	
38,000	.0135		
40,000	.0149		
42,000	.0172		
44,000	.0197		
46,000	.0226		
48,000	.0225		
50,000	.0292		Calked joint is open about ".02. Scale on rivet heads slightly started.
52,000	.0322		
54,000	.0429		
56,000	.0527		
58,000	.0632		
60,000	.0749		
5,000		.0577	
62,000	.0885		
64,000	.1305		
65,200			Ultimate strength.

Failed by shearing three inside rivets and tearing out plate at the end rivets of the upper plate.

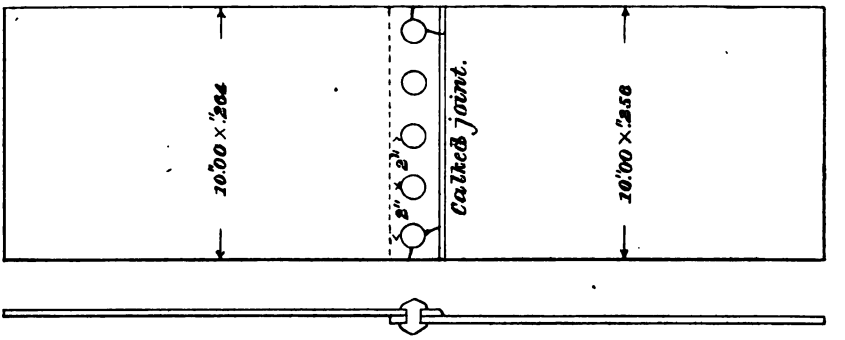
Rivets that were sheared were also fractured under the head.



Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	25,270
Tensile strain on net section of upper plate	38,580
Compressive strain on bearing surface of rivets	73,260
Shearing strain on rivets	34,870

No. 38.—¼″ Iron Plate. Joint C . .



⅝″ iron rivets, "Burden's best."
Drilled holes, ".69 diameter.

	Square inches.
Gross sectional area, upper plate	2.64
Net sectional area, upper plate	1.73
Bearing surface of rivets, upper plate	.911
Shearing area of rivets (".69 diameter)	1.87

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0013	.....	
15,000	.0020	.....	
20,000	.0033	.....	
25,000	.0045	.....	
30,000	.0063	.....	
35,000	.0085	.....	
5,000	.....	.0023	
38,000	.0100	.....	
40,000	.0107	.....	
42,000	.0124	.....	Joint opened ".01, or less.
44,000	.0137	.....	
46,000	.0163	.....	
48,000	.0184	.....	
50,000	.0210	.....	Scale has started on second rivet head.
52,000	.0235	.....	
54,000	.0270	.....	
56,000	.0317	.....	
58,000	.0445	.....	
60,000	.0517	.....	
62,000	.0605	.....	
64,000	.0705	.....	
66,000	.0815	.....	
68,000	.0957	.....	
70,000	.1135	.....	
72,300	.....	.....	Ultimate strength.

Fractured in the same manner as C., by shearing the three inside rivets and tearing out the plate at the end rivets.

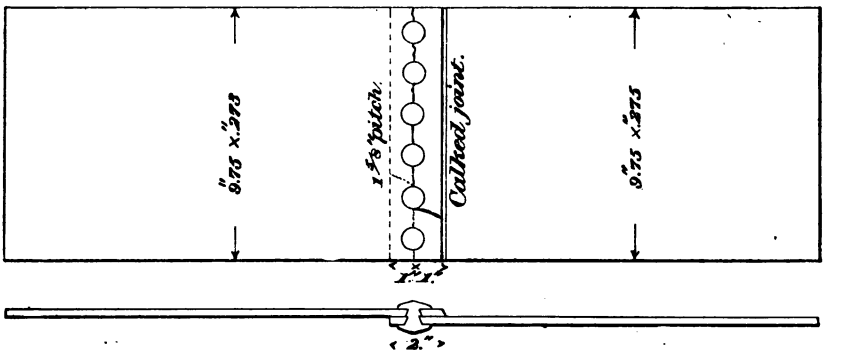
This method of failure would indicate the ability of the plate to shear all the rivets in case the metal at the sides of the specimen was supported and prevented from spreading.

Holes elongated from ".06 to ".08.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	27,380
Tensile strain on net section of upper plate	41,790
Compressive strain on bearing surface of rivets	79,360
Shearing strain on rivets	38,660

No. 39.—¼" IRON PLATE. JOINT D.



⅝" iron rivets, "Burden's best."

Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.66
Net sectional area of plate	1.48
Bearing surface of rivets	1.18
Shearing area of rivets (".70 diameter)	2.31

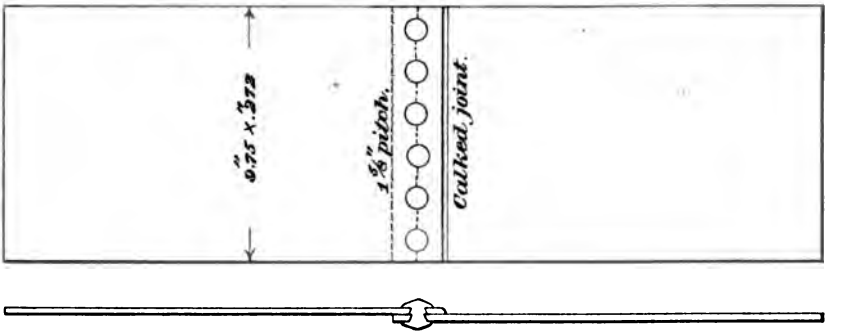
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
15,000	.0021		
20,000	.0036		
25,000	.0051		
30,000	.0071		
35,000	.0101		
5,000		.0029	
38,000	.0117		
40,000	.0132		
42,000	.0151		
44,000	.0171		
46,000	.0193		
48,000	.0223		
50,000	.0251		
52,000	.0293		
54,000	.0331		
56,000	.0373		
58,000	.0422		
60,000	.0501		
62,000	.0571		
64,000	.0651		
66,000	.0760		
68,000	.0830		
70,000	0960		
72,000	.1060		
77,200			Ultimate strength.

Joint failed by fracturing the upper plate across five sections and the under plate across two sections of the plate between rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	29,020
Tensile strain on net section of plate	52,160
Compressive strain on bearing surface of rivets	65,420
Shearing strain on rivets	33,420

No. 40.—¼″ Iron Plate. Joint D . .



⅝″ iron rivets, "Burden's best."

Punched holes: Punch, ″.695 diameter; die, ″.752 diameter.

	Square inches.
Gross sectional area of plate	2.65
Net sectional area of plate	1.48
Bearing surface of rivets	1.18
Shearing area of rivets	2.31

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0007		
15,000	.0020		
20,000	.0032		
25,000	.0050		
30,000	.0070		
35,000	.0094		
5,000		.0032	
38,000	.0114		
40,000	.0132		
42,000	.0150		
44,000	.0167		
46,000	.0192		
48,000	.0217		
50,000	.0252		
52,000	.0292		
54,000	.0322		
56,000	.0358		
58,000	.0397		
60,000	.0462		
62,000	.0510		
64,000	.0572		
66,000	.0640		
68,000	.0714		Joint about ″.05 open.
70,000	.0807		
72,000	.0912		
74,000	.1000		
81,300			Ultimate strength.

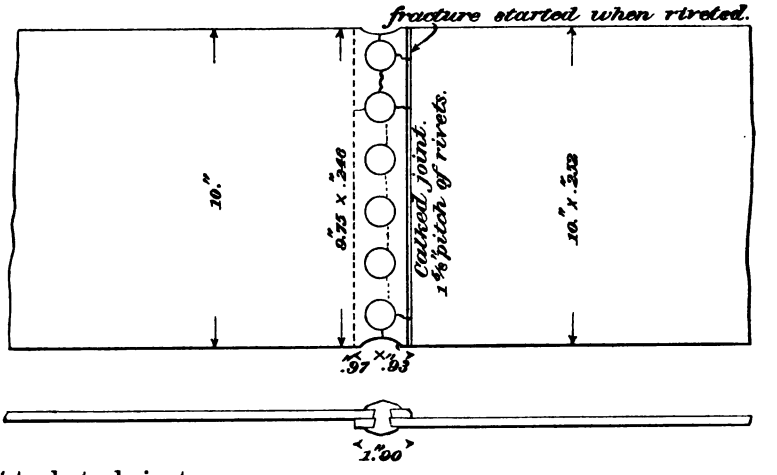
Joint failed by fracturing the lower plate square across through line of rivet holes.

Fractures started slightly at end of plate opposite two rivets.

Maximum loads on joint.

	Pounds. per sq. inch.
Tensile strain on gross section of plate	30,680
Tensile strain on net section of plate	54,930
Compressive strain on bearing surface of rivets	68,890
Shearing strain on rivets	35,200

No. 43.—¼″ Iron Plate. Joint D D.



½″ tool steel rivets.
Punched holes: Punch, ″.568 diameter; die, ″.636 diameter.

	Square inches.
Gross sectional area of upper plate	2.40
Net sectional area of upper plate	1.51
Bearing surface of rivets	.886
Shearing area of rivets (″.57 diameter)	1.53

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0007		
15,000	.0016		
20,000	.0033		
25,000	.0045		
30,000	.0070		
35,000	.0100		
5,000		.0035	
38,000	.0125		
40,000	.0136		Joint started perceptibly.
42,000	.0160		
44,000	.0185		
46,000	.0205		Joint open nearly ″.01.
48,000	.0245		
50,000	.0280		
5,000		.0165	
52,000	.0325		Joint open ″.02.
54,000	.0375		
56,000	.0435		Joint open ″.03.
58,000	.0515		
60,000	.0637		Joint open ″.04.
62,000	.0735		
64,000	.0873		Joint open ″.06.
66,000	.1040		
68,000	.1250		
69,300	.1555		Ultimate strength.

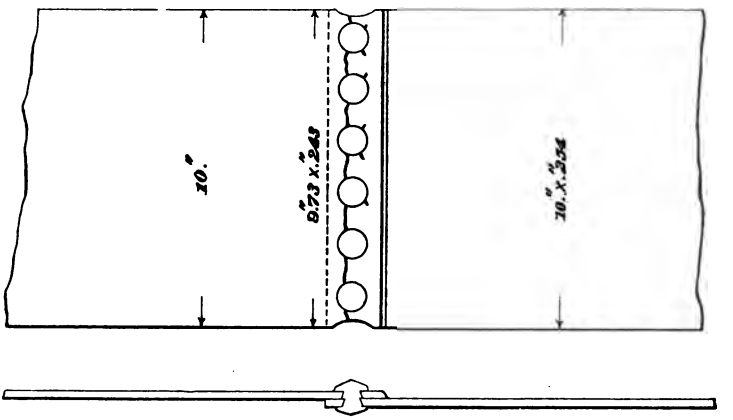
Joint failed by tearing out at two rivets in upper plate and through line of four rivets in under plate. The initial fracture caused by riveting was apparent by a source of weakness. Failure in the under plate appeared wholly due to fractures starting at the rivet holes and tearing till they met. In every case except one, fractures were started at the rivet holes; an examination of the fractured plates would indicate that the failure was due to the excessive compressive strain on the holes, and that by concentrating the strain on $\frac{1}{2}''$ rivets a smaller percentage of the full strength of the plate is obtained than by using $\frac{5}{8}''$ rivets, as was done in experiments D. and D.. It is observed that the fracture in the under plate did not follow a line through the center of the holes, but along a parallel line inside or on the side of the center line opposite the lap end.

The same remarks apply to the position of the fractures started about the rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	28,875
Tensile strain on net section of upper plate	45,890
Compressive strain on bearing surface of rivets	78,220
Shearing strain on rivets	45,300

No. 44.—$\frac{1}{4}''$ IRON PLATE. JOINT D D..



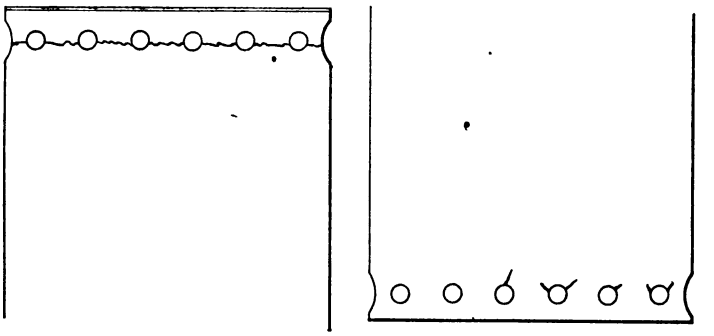
$\frac{1}{2}''$ tool steel rivets.
Punched holes: Punch, ".568 diameter; die, ".636 diameter.

	Square inches.
Gross sectional area of upper plate	2.36
Net sectional area of upper plate	1.49
Bearing surface of rivets	.875
Shearing area of rivets (".57 diameter)	1.53

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0011	.....	
15,000	.0022	.....	
20,000	.0038	.....	
25,000	.0055	.....	
30,000	.0079	.....	
35,000	.0110	.....	
5,000	.....	.0045	
38,000	.0130	.....	
40,000	.0148	.....	Perceptible movement in joint.
42,000	.0165	.....	
44,000	.0185	.....	
46,000	.0209	.....	Joint open ".01.
48,000	.0240	.....	
50,000	.0275	.....	Joint open ".02.
52,000	.0312	.....	
54,000	.0360	.....	Joint open ".03.
56,000	.0408	.....	
58,000	.0455	.....	Joint open ".04.
60,000	.0525	.....	
62,000	.0590	.....	Joint open ".05.
64,000	.0678	.....	
66,000	.0758	.....	
68,000	.0832	.....	
70,000	.0942	.....	
72,000	.1070	.....	
74,000	.1250	.....	
74,080	.1278	.....	Ultimate strength.

Fractured square across upper plate, along a line inside of the center line of rivet holes.

Fracture started about holes in lower plate, as shown by the following sketch:

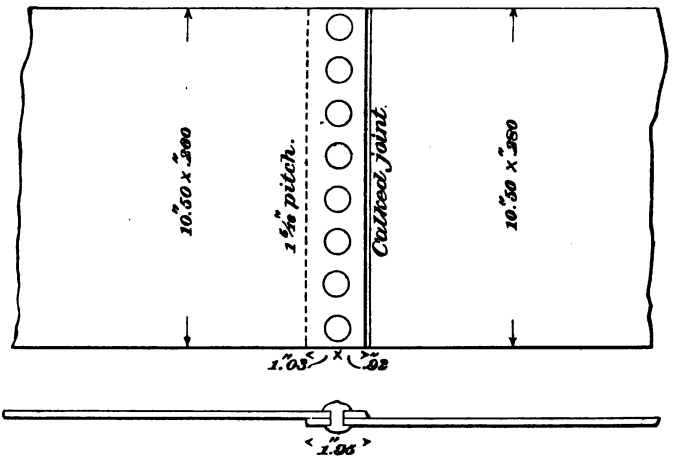


The difference in strength, 4,780 pounds between D D . and D D . . is attributed to the weakening of joint D D . by the riveting at the end section which burst the plate at that place.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	31,390
Tensile strain on net section of upper plate	49,720
Compressive strain on bearing surface of rivets	84,660
Shearing strain on rivets	48,420

No. 45.—¼" IRON PLATE. JOINT H.



Eight $\frac{7}{16}$" iron rivets, "Burden's best."
Drilled holes, ".50 diameter.

	Square inches.
Gross sectional area of upper plate	2.73
Net sectional area of upper plate	1.69
Bearing surface of rivets	1.04
Shearing area of rivets	1.57

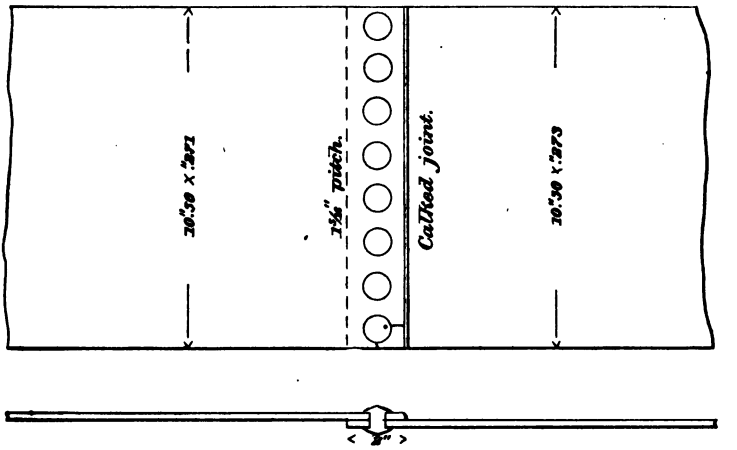
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
15,000	.0018		
20,000	.0030		
25,000	.0050		
30,000	.0090		
35,000	.0130		
5,000		.0068	
38,000	.0158		Joint started perceptibly; slight scaling of rivet heads.
40,000	.0180		
42,000	.0200		Joint open ".01.
44,000	.0235		
46,000	.0268		
48,000	.0305		Joint open ".02.
50,000	.0368		
52,000	.0420		Joint open ".03.
54,000	.0490		
56,000	.0560		
58,000	.0670		Joint open ".05.
60,000	.0758		Joint open ".06.
62,000	.0848		
63,000	.0928		Slight snapping sound.
69,450			Ultimate strength. Sheared the rivets.

Average elongation of rivet holes, ".07.
Fractures started in the outside sections of the plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	25,440
Tensile strain on net section of plate	41,095
Compressive strain on bearing surface of rivets	66,778
Shearing strain on rivets	44,204

No. 46.—1/4" IRON PLATE. JOINT H..



Eight 7/16" iron rivets, "Burden's best."
Drilled holes, 1/2" diameter.

	Square inches.
Gross sectional area of upper plate	2.85
Net sectional area of upper plate	1.76
Bearing surface of rivets	1.084
Shearing area of rivets	1.57

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
15,000	.0008		
20,000	.0018		
25,000	.0040		
30,000	.0070		
35,000	.0120		Scale starts on rivet heads.
5,000		.0072	
38,000	.0160		Joint started perceptibly.
40,000	.0178		
42,000	.0200		
44,000	.0235		
46,000	.0270		Joint open ".01.
48,000	.0335		
50,000	.0398		Joint open ".02.
5,000		.0290	
52,000	.0470		Joint open ".03.
54,000	.0572		Joint open ".04.
56,000	.0665		
58,000	.0770		Joint open ".07.
60,000	.0908		
62,000	.1070		
64,000	.1260		
66,000	.1500		Ultimate strength. Sheared seven rivets, tore out plate at one end rivet.

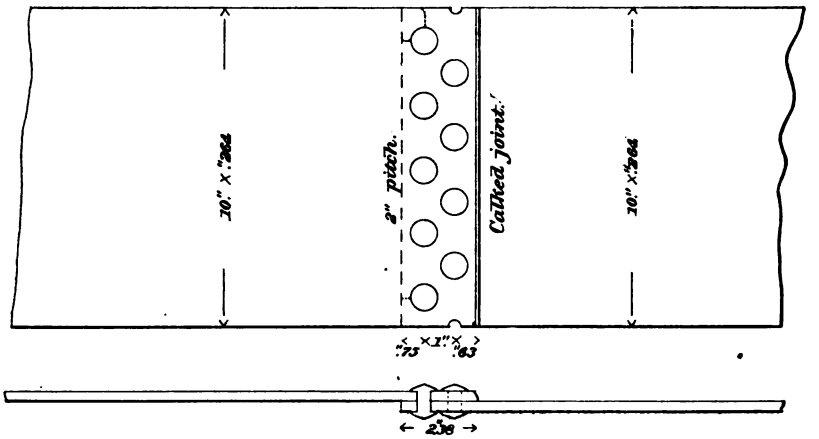
Fractures started about rivet holes.
Average elongation of holes ".09 in plate not fractured.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,158
Tensile strain on net section of plate	37,500
Compressive strain on bearing surface of rivets	60,886
Shearing strain on rivets	42,038

DOUBLE RIVETED LAP JOINTS ¼″ IRON PLATE.

No. 85.—¼″ IRON PLATE. JOINT I.



7/16″ iron rivets, "Burden's best."
Drilled holes, ".50 diameter.

	Square inches.
Gross sectional area of plate	2.64
Net sectional area of plate	1.98
Bearing surface of rivets	1.19
Shearing area of rivets	1.77

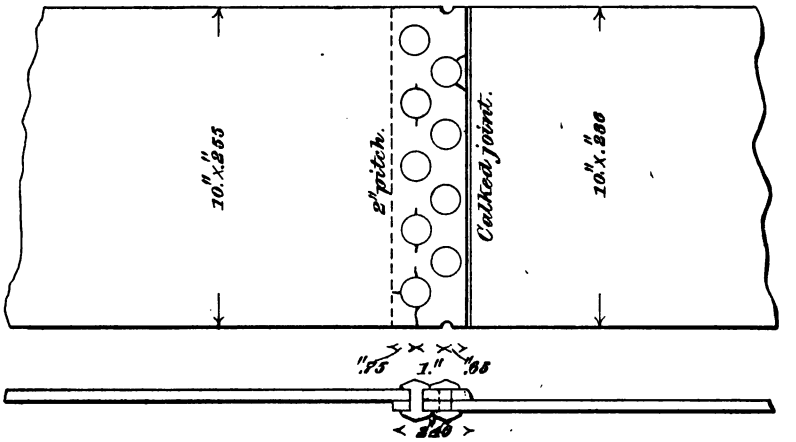
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0009		
20,000	.0030		
30,000	.0065		
40,000	.0128		
45,000	.0168		
50,000	.0212		
55,000	.0362		Joint opened perceptibly.
60,000	.0438		Joint opened ".01.
5,000		.0315	Joint does not close.
65,000	.0600		Joint open ".03.
70,000	.0802		Joint open ".04.
72,000	.0950		Joint open ".06.
74,000	.1180		
76,300			Ultimate strength. Sheared eight rivets tore out plate at one end rivet, started fracture in plate at other end rivet.

Average elongation of holes, ".06.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross area of plate	28,900
Tensile strain on net area of plate	38,535
Compressive strain on bearing surface of rivets	64,120
Shearing strain on rivets	43,110

No. 86.—$\frac{1}{4}$″ IRON PLATE. JOINT I . .



$\frac{7}{16}$″ iron rivets, "Burden's best."
Drilled holes, ".50 diameter.

	Square inches.
Gross sectional area of under plate	2.36
Net sectional area of under plate	1.77
Bearing surface of rivets	1.06
Shearing area of rivets	1.77

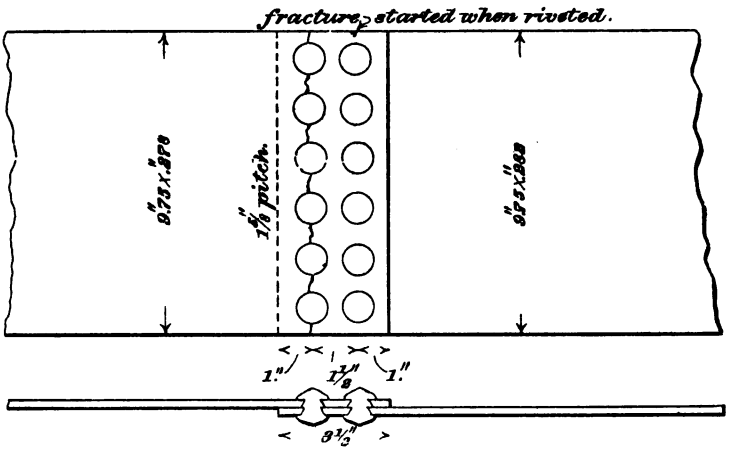
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0025		
30,000	.0060		
35,000	.0098		
40,000	.0130		
45,000	.0170		
50,000	.0220		Joint opened perceptibly.
5,000		.0125	
55,000	.0335		Joint open ".01.
60,000	.0508		
65,000			
73,900			Ultimate strength. Sheared seven rivets, tore out plate at two rivets.

Fractures started about holes in upper plate in the row of five holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	31,314
Tensile strain on net section of under plate	41,750
Compressive strain on bearing surface of rivets	69,710
Shearing strain on rivets	41,750

No. 617.—$\frac{1}{4}$″ Wrought Iron Plate. Plates K.



$\frac{1}{2}$″ iron rivets, "Burden's best."
Punched holes: Punch, $\frac{9}{16}$″ diameter; die, $\frac{21}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	2.71
Net sectional area of upper plate	1.69
Bearing surface of rivets	2.03
Shearing area of rivets	2.98

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0040		Plates not straight; marked in riveting.
20,000	.0145		
30,000	.0220		Elongations include the straightening of the metal.
35,000	.0260		
5,000		.0150	
40,000	.0300		
50,000	.0410		
60,000	.0500		
73,300	.0900		
76,900	.12		
85,500	.22		Ultimate strength.

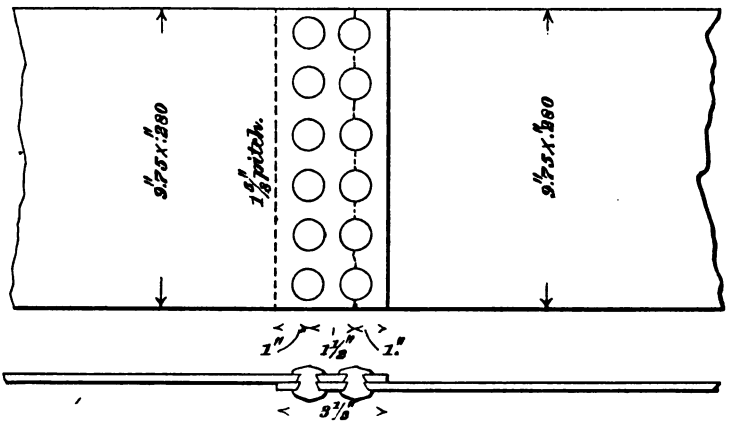
Fractured upper plate across row of rivet holes. Started fractures in upper plate at end of lap.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	31,550
Tensile strain on net section of upper plate	50,592
Compressive strain on bearing surface of rivets	42,118
Shearing strain on rivets	28,691

No. 618.—¼″ IRON PLATE. PLATES K . .

Duplicate of K.



½″ iron rivets, "Burden's best."
Punched holes: Punch, $\frac{9}{16}$″ diameter; die, $\frac{21}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	2.73
Net sectional area of under plate	1.71
Bearing surface of rivets	2.05
Shearing area of rivets	2.98

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0009	.....	
20,000	.0030	.....	
30,000	.0065	.....	
35,000	.0088	.....	
5,000	.....	.0020	
40,000	.0110	.....	
45,000	.0145	.....	
50,000	.0190	.....	
5,000	.....	.0095	
55,000	.0228	.....	
60,000	.0280	.....	
65,000	.0350	.....	
70,000	.06	.....	
75,000	.10	.....	
80,000	.14	.....	
85,000	.19	.....	
85,400	.....	.....	Ultimate strength.

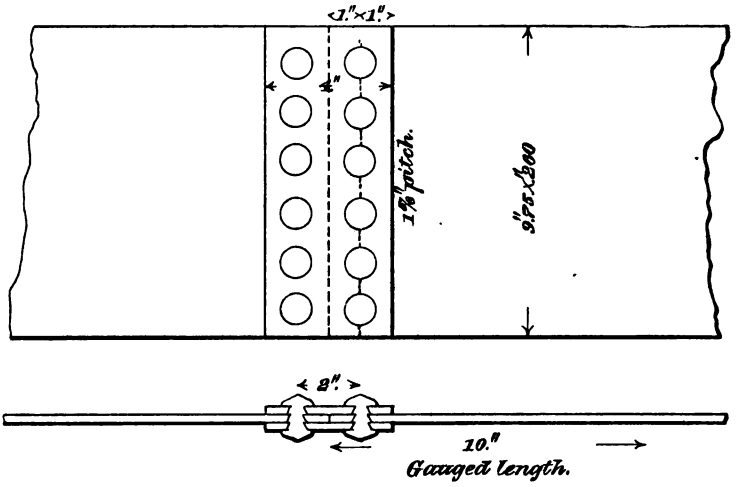
Fractured under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	31,282
Tensile strain on net section of under plate	49,950
Compressive strain on bearing surface of rivets	41,660
Shearing strain on rivets	28,660

SINGLE-RIVETED BUTT JOINTS, ¼″ IRON PLATE.

No. 615.—¼″ IRON PLATE BUTT JOINTS. PLATES L.



⅝″ iron rivets, "Burden's best."
Punched holes: Punch, $\frac{11}{16}$″ diameter; die, ¾″ diameter.

	Square inches
Gross sectional area of plate	2.53
Net sectional area of plate	1.41
Bearing surface of rivets	1.12
Shearing area of rivets	4.45

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
10,000	0.		
15,000	.0010		
20,000	.0021		
25,000	.0035		
30,000	.0045		
35,000	.0055		
10,000		.0002	
40,000	.0075		
45,000	.0110		
50,000	.0130		
55,000	.0160		
60,000	.0190		
10,000		.0110	
70,000	.10		
75,000	.15		
75,400			Ultimate strength.

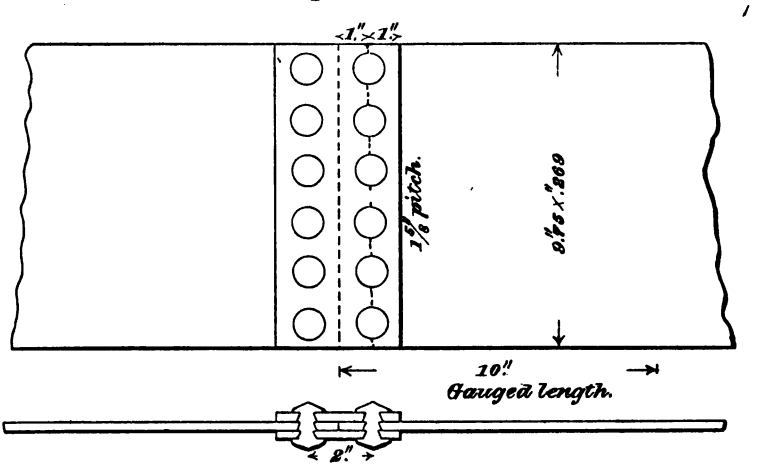
Fractured plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross sectional area of plate	29,800
Tensile strain on net sectional area of plate	53,475
Compressive strain on bearing surface of rivets	67,321
Shearing strain on rivets	16,944

No. 616.—¼″ Iron Plate Butt Joint. Plates L . .

Duplicate of L .



⅝″ iron rivets, "Burden's best."
Punched holes: Punch, $\frac{11}{16}$″ diameter; die, ¾″ diameter.

	Square inches.
Gross sectional area of plate	2.62
Net sectional area of plate	1.46
Bearing surface of rivets	1.16
Shearing area of rivets	4.45

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0010	.....	
20,000	.0028	.....	
30,000	.0050	.....	
35,000	.0060	.....	
5,000	.....	.0009	
40,000	.0070	.....	
42,000	.0075	.....	
44,000	.0080	.....	
46,000	.0085	.....	
48,000	.0090	.....	
50,000	.0098	.....	
52,000	.0105	.....	
54,000	.0111	.....	
56,000	.0121	.....	
58,000	.0132	.....	
60,000	.0150	.....	
62,000	.0168	.....	
64,000	.0180	.....	
66,000	.0200	.....	
68,000	.0255	.....	
70,000	*.06	.....	
74,400	.14	.....	Ultimate strength.

* About ″.06.

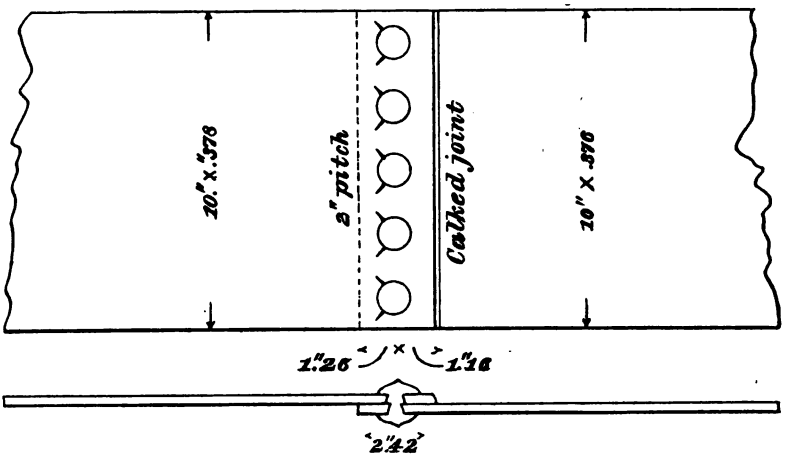
Fractured plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	28,397
Tensile strain on net section of plate	50,959
Compressive strain on bearing surface of rivets	64,138
Shearing strain on rivets	16,719

SINGLE-RIVETED LAP JOINTS ⅜″ IRON PLATE.

No. 62.—⅜″ Iron Plates. Joint A.



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ″.753 diameter; die, ″.774 diameter.

	Square inches.
Gross sectional area of plate	3.76
Net sectional area of plate	2.32
Bearing surface of rivets	1.44
Shearing area of rivets (.″76 diameter)	2.27

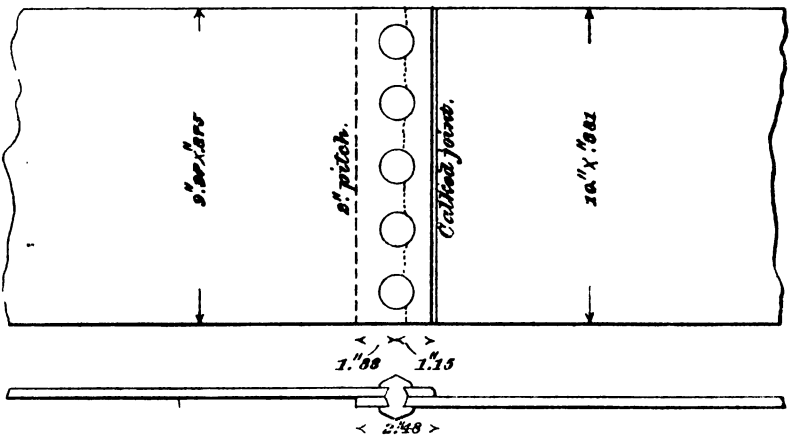
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0048		
35,000	.0070		
5,000		.0040	
40,000	.0100		Joint started slightly.
42,000	.0112		
44,000	.0128		
46,000	.0145		
48,000	.0160		
50,000	.0192		Joint open ″.01. Scale starts on rivet heads about the same time the joint begins to open.
52,000	.0220		
54,000	.0248		
56,000	.0280		
58,000	.0320		
60,000	.0395		Joint open ″.02.
62,000	.0458		Joint open ″.03.
64,000	.0525		
66,000	.0588		Joint open ″.04.
68,000	.0660		Joint open ″.05.
70,000	.0740		
72,000	.0838		
74,000	.0938		
80,000	.1320		
85,000	.1810		
86,900			Ultimate strength. Sheared rivets.

Started fractures about rivet holes inside of center line of holes.
Average elongation of holes, ″.04.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,110
Tensile strain on net section of plate	37,460
Compressive strain on bearing surface of rivets	60,340
Shearing strain on rivets	38,280

No. 63.—⅜″ Iron Plate. Joint A . .



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ″.753 diameter; die, ″.774 diameter.

	Square inches.
Gross sectional area of plate	3.81
Net sectional area of plate	2.35
Bearing surface of rivets	1.46
Shearing area of rivets (″.78 diameter)	2.39

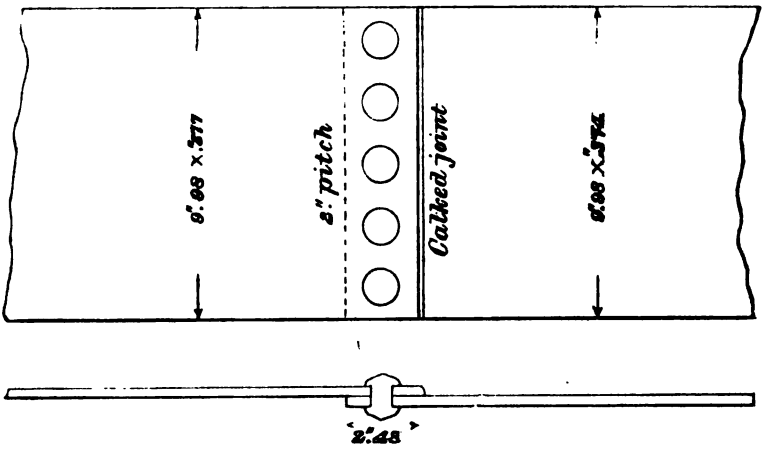
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0012		
30,000	.0039		
35,000	.0065		
5,000		.0032	
40,000	.0090		
45,000	.0121		
50,000	.0170		Joint opened perceptibly.
55,000	.0240		Joint opened ″.01.
60,000	.0389		
65,000	.0560		Joint opened ″.02.
70,000	.0770		Joint opened ″.04.
75,000	.1040		
80,000	.1400		
84,900			Ultimate strength. Fractured the under plate.

Fractures dull fibrous. Fractures started about the rivet holes in the upper plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	22,280
Tensile strain on net section of plate	36,130
Compressive strain on bearing surface of rivets	58,150
Shearing strain on rivets	35,520

No. 64.—⅜″ Iron Plate. Joint C.



$\frac{11}{16}$″ iron rivets, "Burden's best."
Drilled holes, ".77 diameter.

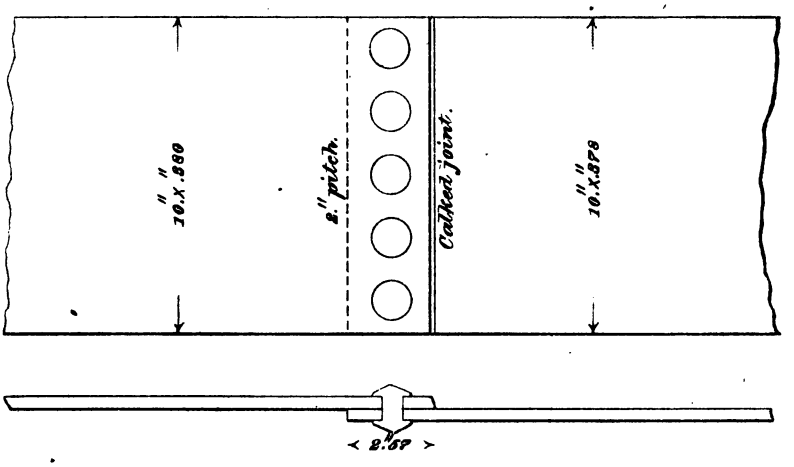
	Square inches.
Gross sectional area of under plate	3.73
Net sectional area of under plate	2.29
Bearing surface of rivets	1.44
Shearing area of rivets (".77 diameter)	2.33

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0012		
30,000	.0029		
35,000	.0042		
5,000		.0015	
40,000	.0090		
45,000	.0142		Joint opened slightly.
50,000	.0182		
5,000		.0118	
55,000	.0238		Joint open ".01.
60,000	.0350		Joint open ".02.
65,000	.0588		Joint open ".04.
70,000	.0798		
75,000	.1080		
87,450			Ultimate strength. Sheared rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,445
Tensile strain on net section of plate	38,190
Compressive strain on bearing surface of rivets	60,730
Shearing strain on rivets	37,530

No. 65.—⅜″ IRON PLATE. JOINT C . .



1⅛″ iron rivets, "Burden's best."
Drilled holes, ″.77 diameter.

	Square inches.
Gross sectional area of under plate	3.78
Net sectional area of under plate	2.32
Bearing surface of rivets	1.46
Shearing area of rivets	2.33

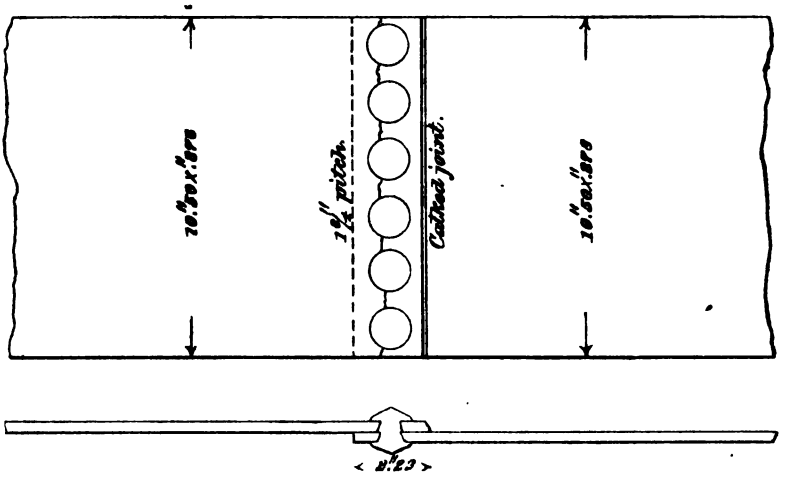
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
20,000	.0028		
30,000	.0062		
35,000	.0092		
5,000		.0040	
40,000	.0120		Joint opened perceptibly.
45,000	.0160		
50,000	.0230		Joint open ″.01.
5,000		.0130	
55,000	.0328		Joint open ″.02.
60,000	.0495		Joint open ″.04.
65,000	.0680		Joint open ″.05.
70,000	.0940		
75,000	.1260		
84,000			Ultimate strength. Sheared rivets.

Average elongation of drilled holes, ″.05.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	22,220
Tensile strain on net section of plate	36,210
Compressive strain on bearing surface of rivets	57,530
Shearing strain on rivets	36,050

No. 66.—$\frac{3}{8}$″ Iron Plate. Joint D.



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

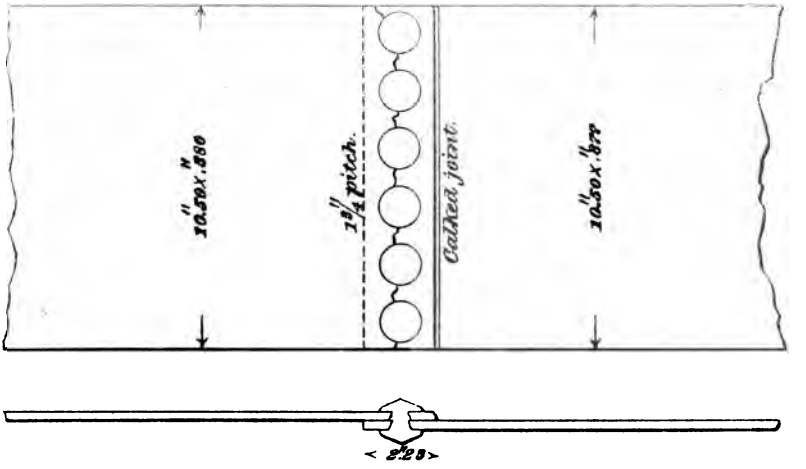
	Square inches
Gross sectional area of upper plate	3.95
Net sectional area of upper plate	2.23
Bearing surface of rivets	1.72
Shearing area of rivets	2.72

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0040		
35,000	.0060		
5,000		.0022	
40,000	.0082		
45,000	.0110		
50,000	.0150		
5,000		.0080	
55,000	.0202		Joint opened perceptibly.
60,000	.0250		
65,000	.0335		Joint open ".01.
70,000	.0460		Joint open ".02.
75,000	.0638		Joint open ".03.
80,000	.0850		Joint open ".05.
85,000	.1600		
93,100			Ultimate strength. Fractured plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross area of plate	23,570
Tensile strain on net area of plate	41,750
Compressive strain on bearing surface of rivets	54,130
Shearing strain on rivets	

No. 67.—$\frac{3}{8}$″ Iron Plate. Joint D . .



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

Note.—Before the test incipient fractures were observed at the side of the plates in the center line of the rivet holes, probably caused by the machine reveting.

	Square inches.
Gross sectional area of upper plate	3.99
Net sectional area of upper plate	2.25
Bearing surface of rivets	1.74
Shearing area of rivets (".76 diameter)	2.72

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0028		
30,000	.0055		
35,000	.0078		
5,000		.0025	
40,000	.0108		
45,000	.0140		
50,000	.0180		
5,000		.0080	
55,000	.0235		
60,000	.0320		Joint opened perceptibly.
65,000	.0430		Joint open ".01.
70,000	.0585		Joint open ".02.
75,000	.0745		Joint open ".03.
80,000	.1180		
92,900			Ultimate strength. Fractured upper plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,280
Tensile strain on net section of plate	41,290
Compressive strain on bearing surface of rivets	53,400
Shearing strain on rivets	34,150

No. 721.—$\frac{3}{8}$″ Iron Plate. Set K . .

Duplicate of K . No. 720.

Upper plate, 10″.32 × ″.395.
Under plate, 10″.32 × ″.395.
1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches
Gross sectional area of under plate	4.08
Net sectional area of under plate	1.88
Bearing surface of rivets	2.19
Shearing area of rivets	4.43

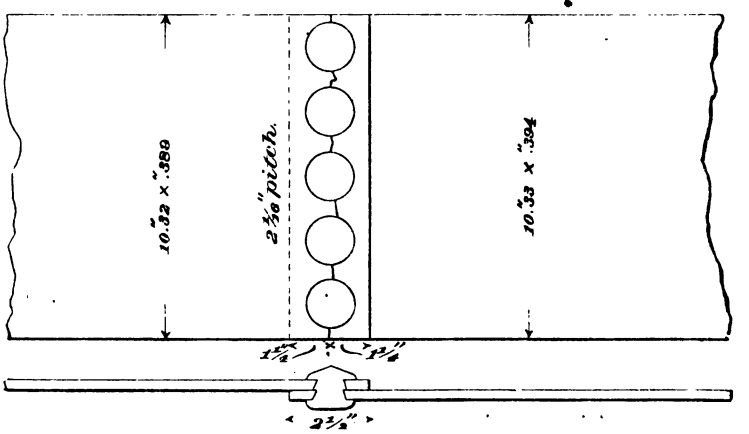
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0015		
20,000	.0040		
30,000	.0080		
35,000	.0098		
40,000	.0125		
45,000	.0155		
50,000	.0200		
55,000	.0240		
60,000	.0290		
65,000	.0350		
70,000	.0455		
75,000	.0560		
80,000	.0670		
90,000	.10		
100,000	.15		
110,000	.21		Ultimate strength.

Fractured under plate across line of rivet holes. Broke suddenly.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	26,960
Tensile strain on net section of under plate	58,510
Compressive strain on bearing surface of rivets	50,220
Shearing strain on rivets	24,830

No. 720.—$\frac{3}{8}$″ Iron Plate. Set K .



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	4.07
Net sectional area of under plate	1.88
Bearing surface of rivets	2.19
Shearing area of rivets	4.43

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
50,000	.03		
60,000	.05		
70,000	.06		
80,000	.07		
90,000	.08		
100,000	.12		
110,000	.19		
116,000	.25		Ultimate strength.

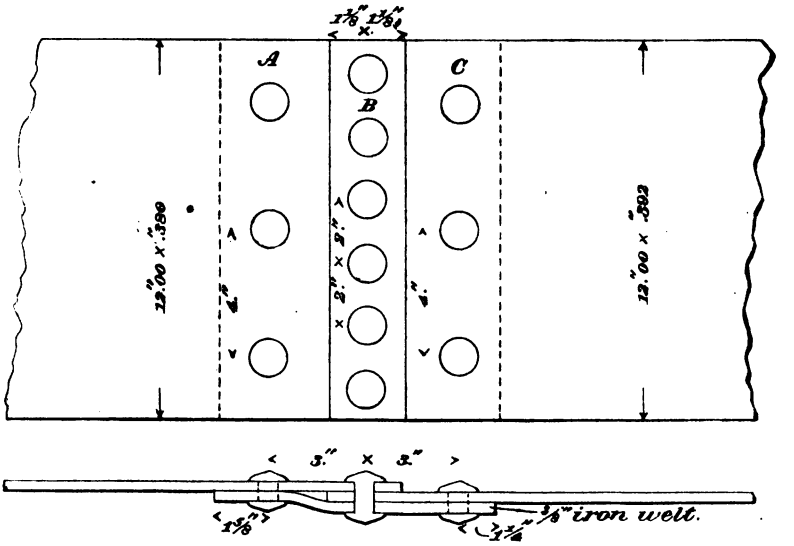
Joint failed suddenly, fracturing under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	28,500
Tensile strain on net section of under plate	61,700
Compressive strain on bearing surface of rivets	52,970
Shearing strain on rivets	26,180

SINGLE-RIVETED LAP JOINTS WITH REINFORCED WELT. $\frac{1}{4}$" IRON PLATE.

No. 244.—$\frac{3}{8}$" IRON PLATE. JOINT J.



$\frac{5}{8}$" iron rivets, "Burden's best."
Drilled holes, ".72 diameter.
Welt, $\frac{3}{8}$" iron plate.

	Square inches.
Gross sectional area of upper plate	4.63
Net sectional area of upper plate through line rivets *B*	2.96
Net sectional area of upper plate through line rivets *A*	3.80
Bearing surface of rivets, upper plate	2.50
Shearing area of rivets (9 rivets), single shear	3.66

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0032		
35,000	.0040		
5,000		.0005	
40,000	.0050		
45,000	.0062		
50,000	.0072		
55,000	.0088		
60,000	.0105		
5,000		.0030	
65,000	.0129		Scale started around outside rows of rivets.
70,000	.0150		
75,000	.0175		
80,000	.0198		
85,000	.0220		
90,000	.0240		
95,000	.0278		
100,000	.0310		
5,000		.0181	
105,000	.0400		Micrometer removed.
110,000	.05		
115,000	.06		
120,000	.06		
125,000	.08		
130,000	.11		
135,000	.14		
140,000	.17		
145,000	.25		
147,700			Ultimate strength. Sheared nine rivets, rows *A* and *B*.

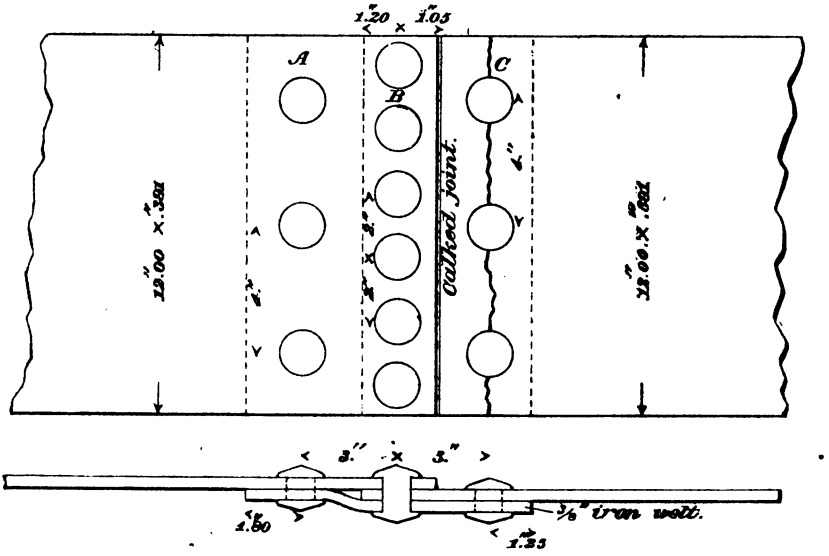
"Cooper lines" run from rivets in row *A*, at an angle of 53 degrees with direction of pull on the specimen.

Elongation of holes, row *A*, ".08; row *B*, ".03.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	31,900
Tensile strain on net section of upper plate through line of rivet holes *B*	49,900
Tensile strain on net section of upper plate through line of rivet holes *A*	38,870
Compressive strain on bearing surface of rivets	59,080
Shearing strain on rivets (9 rivets)	40,360

No. 245.—⅜″ Iron Plate. Joint J . .



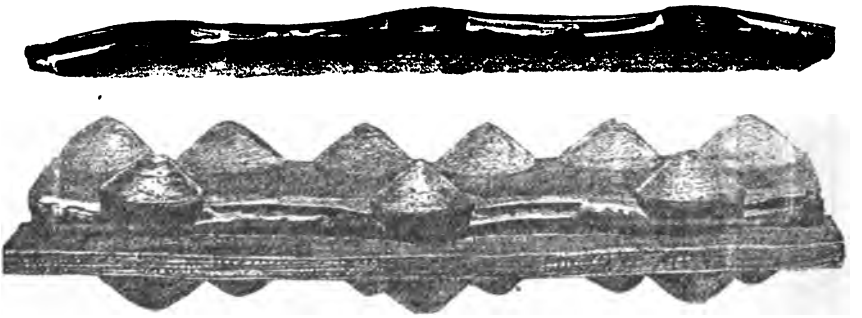
¾″ iron rivets, "Burden's best."
Drilled holes, ".82 diameter.
Welt, ⅜″ iron plate.

	Square inches.
Gross sectional area of under plate	4.69
Net sectional area of under plate through line of rivet holes *B*	2.77
Net sectional area of under plate through line of rivet holes *C*	3.74
Bearing surface of nine rivets (".82 diameter)	2.89
Shearing area of nine rivets, single shear	4.75

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0011		
30,000	.0025		
35,000	.0030		
5,000		.0005	
40,000	.0038		
50,000	.0050		
60,000	.0070		
5,000		.0019	
70,000	.0120		
75,000	.0150		
80,000	.0175		Joint opened perceptibly.
85,000	.0195		
90,000	.0220		Joint open ".01.
95,000	.0245		
100,000	.0280		
5,000		.0165	
105,000	.0310		
110,000	.0350		
115,000	.0435		Joint open ".02.
120,000	.0550		Micrometer removed.
125,000	.07		
130,000	.09		Joint open about ".04.
135,000	.10		
140,000	.13		
145,000	.18		
163,700			Ultimate strength. Fractured lower plate through outside line of rivet holes.

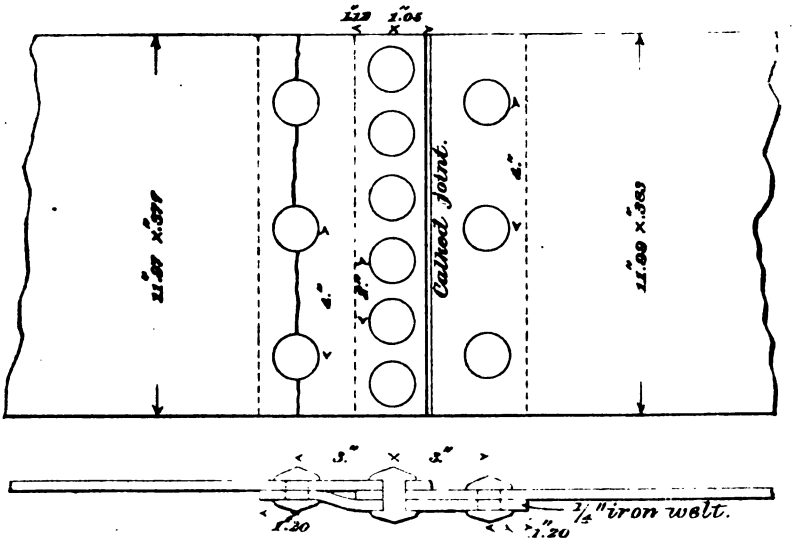
Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	34,900
Tensile strain on net section of under plate through line of rivets *B*	59,100
Tensile strain on net section of under plate through line of rivets *C*	43,770
Compressive strain on bearing surface of rivets (9)	56,640
Shearing strain on nine rivets (single shear)	34,460



Photograph Joint No. 245.

No. 296.—$\frac{3}{8}$″ Iron Plate. Joint J J.



$\frac{3}{4}$″ iron rivets, "Burden's best."
Drilled holes, ″.82 diameter.

	Square inches.
Gross sectional area of upper plate	4. 51
Net sectional area of upper plate through line of three rivet holes	3. 59
Bearing surface of rivets	2. 78
Shearing area of rivets (single shear, 9 rivets)	4. 75

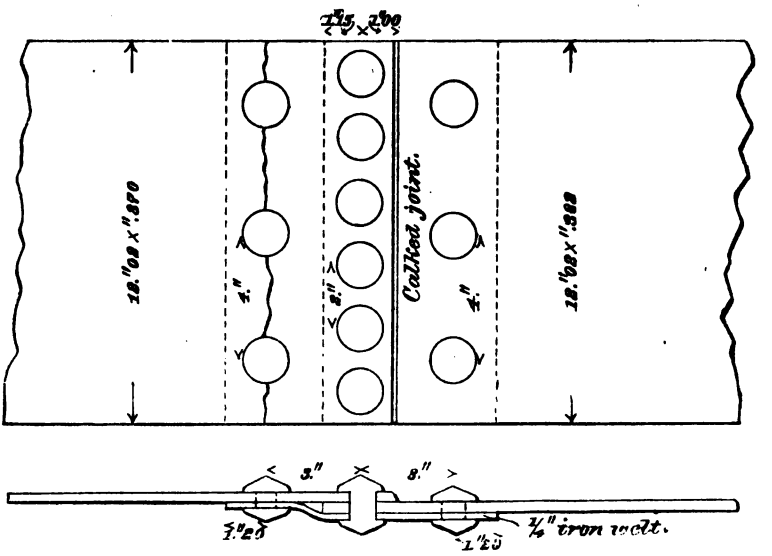
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0010		
30,000	.0020		
35,000	.0030		
5,000		.0005	
40,000	.0038		
50,000	.0068		
60,000	.0108		
70,000	.0150		
80,000	.0190		
90,000	.0245		
100,000	.0318		
110,000	.0430		
120,000	.07		
130,000	.10		
140,000	.16		
161,000			Ultimate strength.

Fractured upper plate through rivet holes line *A*.
Fibrous fracture.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	35,700
Tensile strain on net section of upper plate across row of three rivet holes	44,840
Compressive strain on bearing surface of rivets	57,910
Shearing strain on rivets (9 rivets, single shear)	33,890

No. 297.—$\frac{3}{8}$″ Iron Plate. Joint J J . .



¾″ iron rivets, "Burden's best."
Drilled holes, ".82 diameter.

	Square inches.
Gross sectional area of upper plate	4.45
Net sectional area of upper plate through line of three rivet holes	3.54
Bearing surface of rivets	2.73
Shearing area of rivets (single shear, 9 rivets)	4.75

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0030		
35,000	.0038		
5,000		.0005	
40,000	.0045		
45,000	.0050		
50,000	.0060		
55,000	.0070		
60,000	.0090		
65,000	.0115		
70,000	.0145		
75,000	.0180		
80,000	.0208		
85,000	.0230		
90,000	.0268		
95,000	.0292		
100,000	.0340		
110,000	.0470		
120,000	.08		
130,000	.11		
140,000	.17		
151,100			Ultimate strength.

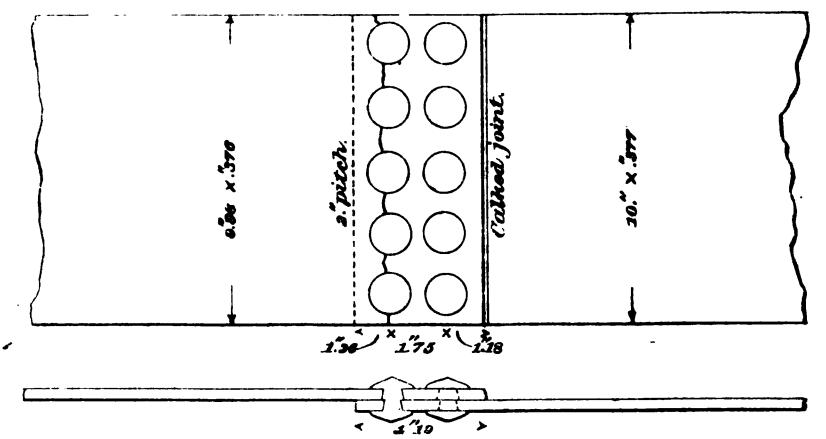
Fractured upper plate through outside row of rivet holes. Fibrous fracture.

Maximum loads on joint.

	Pounds per sq. inch
Tensile strain on gross section of upper plate	33,950
Tensile strain on net section of upper plate through row of three rivet holes	42,680
Compressive strain on bearing surface of rivets	55,350
Shearing strain on rivets	31,810

DOUBLE-RIVETED LAP JOINTS $\frac{3}{8}$" IRON PLATE.

No. 68.—$\frac{3}{8}$" IRON PLATE. JOINT F.



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

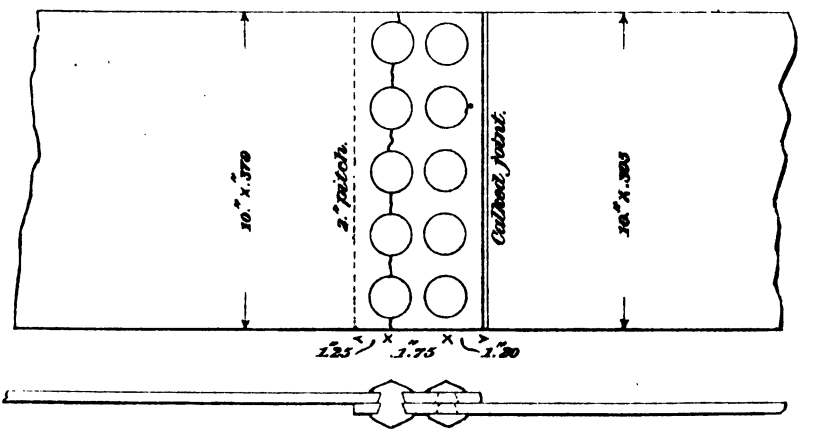
	Square inches.
Gross sectional area of upper plate	3.75
Net sectional area of upper plate	2.32
Bearing surface of rivets	2.87
Shearing area of rivets (".76 diameter)	4.54

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0020		
30,000	.0040		
35,000	.0050		
5,000		.0010	
40,000	.0068		
45,000	.0080		
50,000	.0100		
55,000	.0125		
60,000	.0155		
65,000	.0195		Joint opened perceptibly.
70,000	.0238		Joint open ".01.
5,000		.0140	
75,000	.0285		Joint open ".03.
80,000	.0335		Joint open ".04.
85,000	.0392		
90,000	.0460		Joint open ".05.
95,000	.0530		
112,400			Ultimate strength. Fractured upper plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross area of plate	29,970
Tensile strain on net section of plate	48,450
Compressive strain on bearing surface of rivets	39,160
Shearing strain on rivets	24,760

No. 69.—$\frac{3}{8}$" IRON PLATE. JOINT F . .



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of upper plate	3.79
Net sectional area of upper plate	2.34
Bearing surface of rivets	2.89
Shearing area of rivets (".76 diameter)	4.54

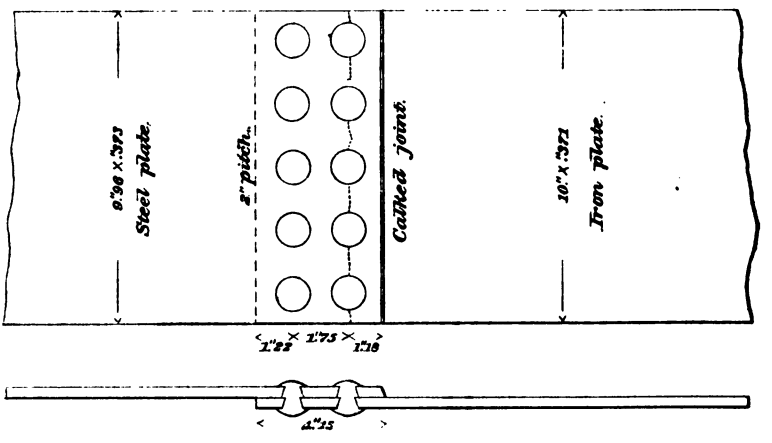
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,00	0.		
10,000	.0005		
20,000	.0020		
30,000	.0032		
35,000	.0045		
5,000		.0006	
40,000	.0058		
45,000	.0071		
50,000	.0082		
55,000	.0102		
60,000	.0125		
65,000	.0151		
70,000	.0182		Joint opened perceptibly.
5,000		.0070	
75,000	.0231		
80,000	.0280		Joint open ".01+.
85,000	.0340		Joint open ".02.
90,000	.0400		Joint open ".03.
95,000	.0485		
118,700			Ultimate strength. Fractured upper plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross area of plate	31,320
Tensile strain on net area of plate	50,730
Compressive strain on bearing surface of rivets	41,070
Shearing strain on rivets	26,150

Photograph of fractured plate, Joint No. 69, showing eccentricity of rivet heads; also showing scale started off rivet heads caused by the bending of the joint plates.

No. 58.—$\frac{3}{8}$″ Iron and Steel Plate. Joint F . . .



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of iron plate	3.71
Net sectional area of iron plate	2.29
Bearing surface of rivets	2.83
Shearing area of rivets (".76 diameter)	4.54

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
20,000	.0025		
30,000	.0042		
40,000	.0070		
45,000	.0081		
50,000	.0100		
5,000		.0038	
55,000	.0120		
60,000	.0140		Joint opened perceptibly.
65,000	.0162		
70,000	.0192		Joint open ".01.
5,000		.0090	
75,000	.0238		Joint open ".02.
80,000	.0280		
85,000	.0329		Joint open ".03.
90,000	.0378		
5,000		.0258	
95,000	.0435		Joint open ".04.
100,000	.0508		Joint open ".05.
105,000	.0608		
110,000	.0768		
115,000			Ultimate strength.

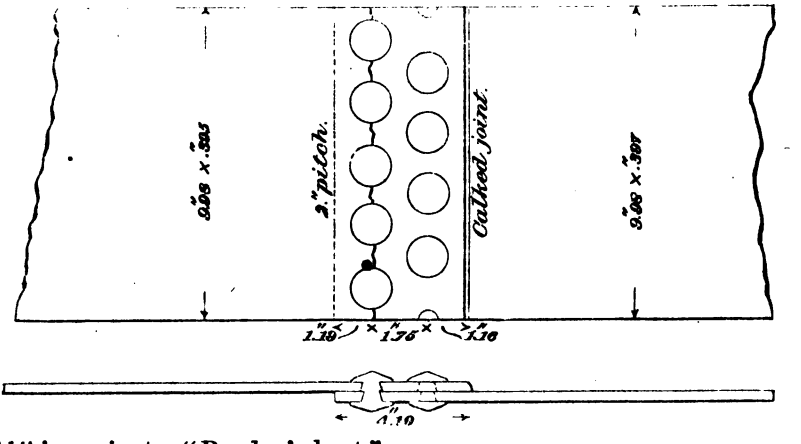
Fractured lower plate across line of rivet holes. Fibrous fractures, metal slightly drawn down.

NOTE.—Through mistake an iron and a steel plate were riveted together.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of iron plate	31,000
Tensile strain on net section of iron plate	50,220
Compressive strain on bearing surface of rivets	40,640
Shearing strain on rivets	25,330

No. 70.—⅜" IRON PLATE. JOINT G.



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of upper plate	3.94
Net sectional area of upper plate	2.43
Bearing surface of rivets	2.71
Shearing area of rivets (".76 diameter)	4.08

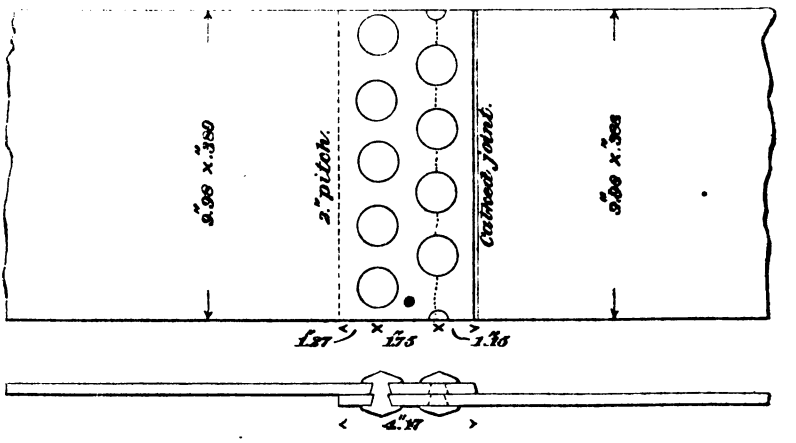
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0020		
30,000	.0038		
35,000	.0048		
5,000		.0010	
40,000	.0068		
45,000	.0079		
50,000	.0095		
55,000	.0120		
60,000	.0145		
65,000	.0178		
70,000	.0210		Joint opened perceptibly.
75,000	.0258		Joint open ".01.
5,000		.0141	
80,000	.0300		
85,000	.0348		Joint open ".02.
90,000	.0410		Joint open ".03.
95,000	.0488		Joint open ".04.
100,000	.0630		
112,400			Ultimate strength. Fractured upper plate through row of five rivet holes.

Fractured plate shows imperfect welds in rolling.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	28,530
Tensile strain on net section of plate	46,255
Compressive strain on bearing surface of rivets	41,480
Shearing strain on rivets	27,550

No. 71.—$\frac{3}{8}$" Iron Plate. Joint G . .



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

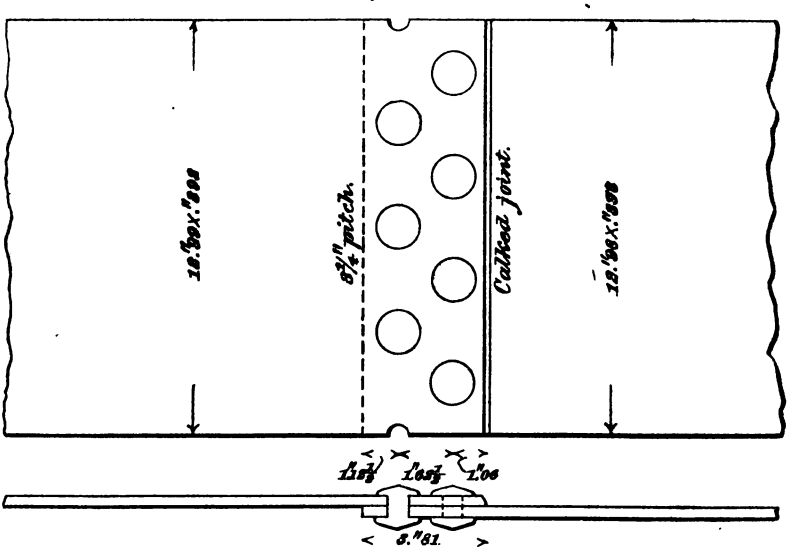
	Square inches.
Gross sectional area of under plate	3.87
Net sectional area of under plate	2.39
Bearing surface of rivets	2.67
Shearing area of rivets (".76 diameter)	4.08

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0020		
30,000	.0040		
35,000	.0050		
5,000		.0005	
40,000	.0065		
45,000	.0080		
50,000	.0105		
55,000	.0130		
60,000	.0160		Joint opened perceptibly.
65,000	.0198		Joint open ".01.
70,000	.0240		Joint open ".02.
75,000	.0290		Joint open ".03.
80,000	.0348		Joint open ".04.
85,000	.0399		
90,000	.0468		
95,000	.0555		
100,000	.0680		
110,200			Ultimate strength. Fractured the under plate through line of four rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	28,475
Tensile strain on net section of plate	46,110
Compressive strain on bearing surface of rivets	41,270
Shearing strain on rivets	27,010

No. 81.—⅜" Iron Plate. Joint I.



11/16" iron rivets, "Burden's best."
Drilled holes, ".75 diameter.

	Square inches.
Gross sectional area of upper plate	5.09
Net sectional area of upper plate	3.91
Bearing surface of rivets	2.06
Shearing area of rivets (".75 diameter)	3.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	0.		
20,000	.0002		
30,000	.0009		
40,000	.0020		
50,000	.0050		
55,000	.0070		
60,000	.0098		
65,000	.0120		
5,000		.0050	
70,000	.0150		
75,000	.0190		
80,000	.0250		
85,000	.0362		Joint opened perceptibly.
90,000	.0458		Joint open ".01+
95,000	.0580		Joint open ".03.
100,000	.0708		Joint open ".06.
105,000	.0880		
110,000	.1080		
115,000	.1350		
120,900			Ultimate strength. Sheared rivets.

Average elongation of holes, ".04.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,750
Tensile strain on net section of plate	30,920
Compressive strain on bearing surface of rivets	58,700
Shearing strain on rivets	39,130

No. 82.—$\frac{3}{8}$" Iron Plate. Joint I . .

Same style of joint as No. 81.
Upper plate, 12".97 × ".395.
Under plate, 12".97 × ".395.
$\frac{11}{16}$" iron rivets, "Burden's best."
Drilled holes, ".75 diameter.

	Square inches.
Gross sectional area of plate	5.12
Net sectional area of plate	3.94
Bearing surface of rivets	2.07
Shearing area of rivets (".75 diameter)	3.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0002	.....	
20,000	.0012	.....	
30,000	.0028	.....	
40,000	.0050	.....	
50,000	.0120	.....	
55,000	.0140	.....	
60,000	.0170	.....	
65,000	.0210	.....	
5,000	.....	.0145	
70,000	.0255	.....	
75,000	.0300	.....	
80,000	.0400	.....	Joint opened ".01.
85,000	.0510	.....	
90,000	.0608	.....	Joint opened ".02.
95,000	.0750	.....	Joint opened ".04.
100,000	.0890	.....	Joint opened ".06.
105,000	.1080	.....	
118,700	.....	.....	Ultimate strength. Sheared rivets.

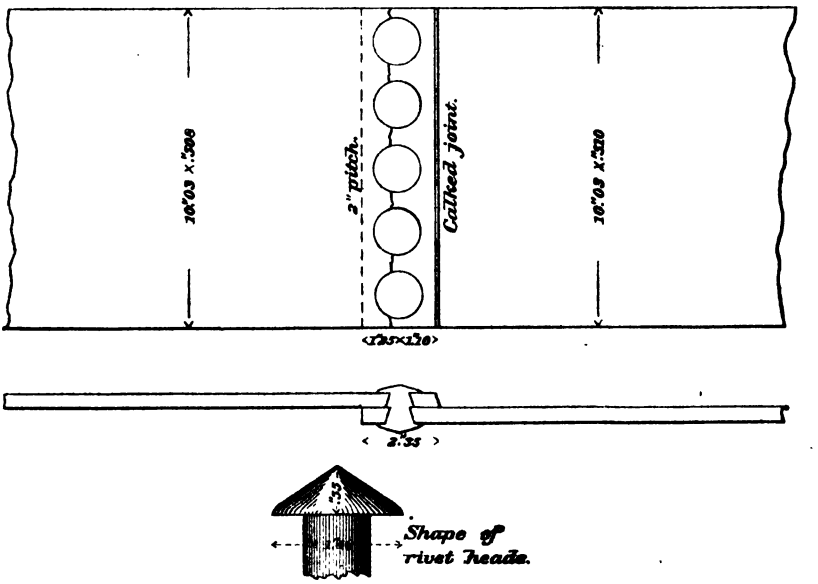
Average elongation of rivet holes, ".06.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,180
Tensile strain on net section of plate	30,130
Compressive strain on bearing surface of rivets	57,340
Shearing strain on rivets	38,410

SINGLE AND DOUBLE RIVETED LAP JOINTS, ¼" IRON PLATE.

No. 240.—½" IRON PLATE. JOINT A.



⅝" iron rivets, "Burden's best."
Punched holes: Punch, $\frac{13}{16}$" diameter; die, $\frac{11}{12}$" diameter.

	Square inches.
Gross sectional area of upper plate	5.095
Net sectional area of upper plate	2.91
Bearing surface of rivets	2.18
Shearing area of rivets (".82 diameter)	2.64

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0020		
30,000	.0042		
35,000	.0068		
5,000		.0025	
40,000	.0108		
45,000	.0148		Joint opened perceptibly.
50,000	.0172		
5,000		.0085	
55,000	.0199		
60,000	.0230		
65,000	.0298		Joint open ".01.
70,000	.0418		Joint open ".01½.
5,000		.0265	
10,000	.0280		
20,000	.0308		
30,000	.0330		
40,000	.0358		
50,000	.0380		
5,000		.0268	
10,000	.0280		
20,000	.0308		
30,000	.0330		
40,000	.0358		
50,000	.0380		
70,000	.0428		
75,000	.0548		
80,000	.0718		
5,000		.0540	
10,000	.0560		
20,000	.0588		
30,000	.0610		
40,000	.0638		
50,000	.0658		Micrometer removed.
85,000	.10		Joint open ".04.
90,000	.15		
90,500			Ultimate strength.

Fractured top plate, the line of the fracture following about ".08 back of center line of rivet holes.

The plate that fractured had the die side in contact with lower plate.

Metal fibrous, except around the punched holes, which was granular; on the punch side of the plate little or no granulation was found, but on the die side the ring of granular metal reached the maximum amount of $\frac{1}{10}$" thickness.

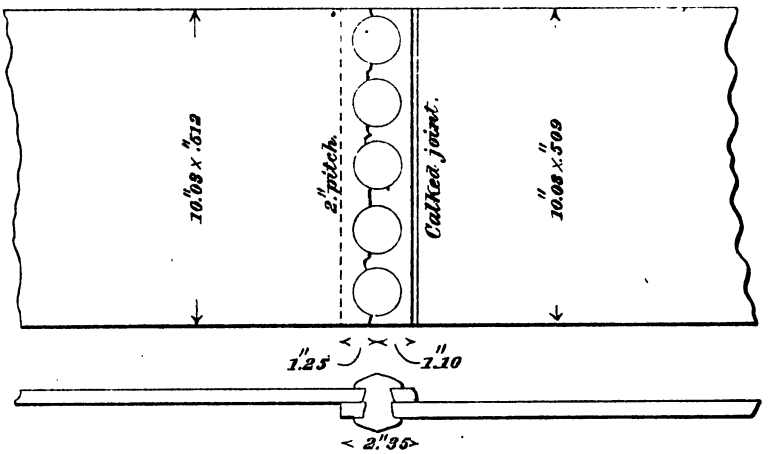
Along the calked edge granular metal was found. At 50,000 pounds tension snapping sounds were heard, which were repeated occasionally till fracture took place. These sounds were attributed to the supposed giving way of the granular metal about the rivet holes, from time to time, as the plates bent at the joint.

Fractures were started about the holes in the under plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	17,760
Tensile strain on net section of plate	31,100
Compressive strain on bearing surface of rivets	41,500
Shearing strain on rivets	34,280

No. 241.—½″ IRON PLATE. JOINT A . .



⅞″ iron rivets, "Burden's best."
Punched holes: Punch, $1\frac{3}{16}$″ diameter; die, $\frac{29}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	5.14
Net sectional area of upper plate	2.94
Bearing surface of rivets	2.20
Shearing area of rivets (".82 diameter)	2.64

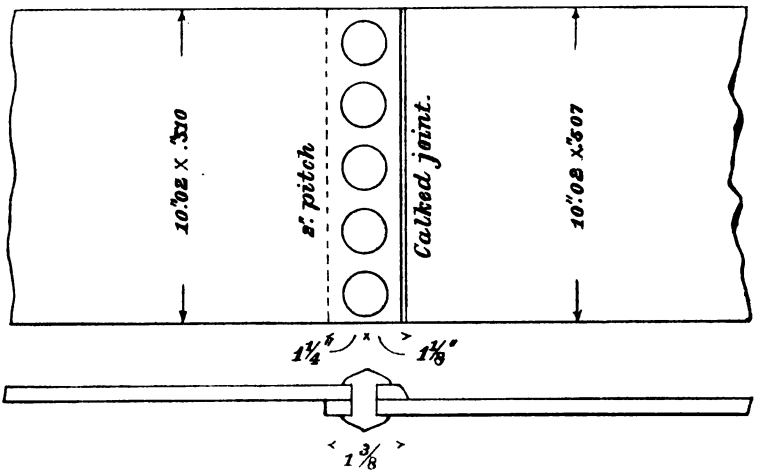
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0020		
30,000	.0038		
35,000	.0052		
5,000		.0019	
10,000	.0021		
20,000	.0035		
30,000	.0049		
35,000	.0055		
5,000		.0019	
10,000	.0022		
20,000	.0038		
30,000	.0049		
35,000	.0058		
40,000	.0085		
45,000	.0121		
50,000	.0155		
5,000		.0080	
10,000	.0085		
20,000	.0100		
30,000	.0112		
40,000	.0132		
50,000	.0160		
55,000	.0190		
60,000	.0221		
65,000	.0268		Joint opened perceptibly.
70,000	.0370		Joint opened ".01.
75,000	.0500		Micrometer removed.
80,000	.07		
85,000	.09		
90,000	.13		
92,300			Ultimate strength. Fractured upper plate.
70,000			Load at time of fracture.

Fractured in the same manner as A . Same description of appearance of fractures.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	17,690
Tensile strain on net section of plate	31,395
Compressive strain on bearing surface of rivets	41,955
Shearing strain on rivets	34,960

No. 292.—½″ Iron Plate. Joint A A.



⅞″ iron rivets, "Burden's best."
Drilled holes, ".81 diameter.

	Square inches.
Gross sectional area of lower plate	5.08
Net sectional area of lower plate	3.03
Bearing surface of rivets	2.05
Shearing area of rivets (".81 diameter)	2.58

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0002	.....	
20,000	.0008	.....	
30,000	.0022	.....	
35,000	.0032	.....	
5,000	.....	.0006	
40,000	.0065	.....	
45,000	.0108	.....	
50,000	.0148	.....	Joint opened perceptibly.
5,000	.....	.0085	
55,000	.0190	.....	
60,000	.0222	.....	
65,000	.0280	.....	Joint opened ".01.
70,000	.0405	.....	
75,000	.0570	.....	Joint open ".02.
80,000	.0760	.....	
85,000	.10	.....	Joint open ".05.
90,000	.13	.....	
95,000	.16	.....	
98,100	.19	.....	Ultimate strength. Sheared rivets.

Average elongation of rivet holes, ".09.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	19,130
Tensile strain on net section of under plate	32,376
Compressive strain on bearing surface of rivets	47,850
Shearing strain on rivets	38,020

No. 293.—½" Iron Plate. Joint A A . .

Same style of joint as No. 292.
Upper plate, 10".03 × ".510.
Under plate, 10".03 × ".510.
¾" iron rivets, "Burden's best."
Drilled holes, ".81 diameter.

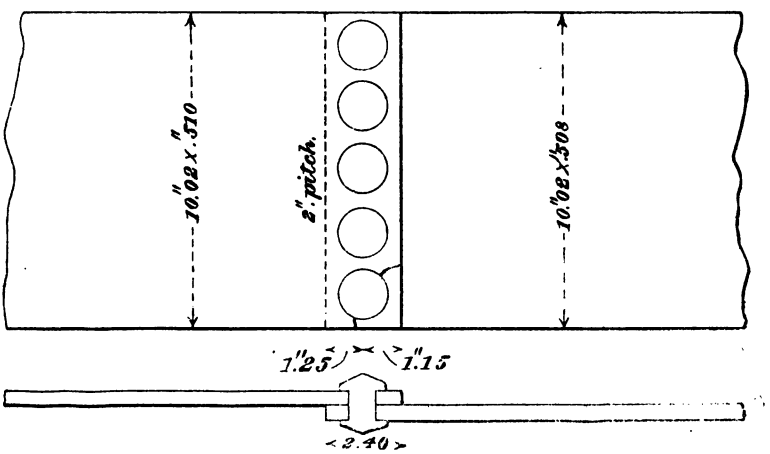
	Square inches.
Gross sectional area of plate	5.12
Net sectional area of plate	3.05
Bearing surface of rivets	2.07
Shearing area of rivets	2.58

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	.0019		
25,000	.0028		
30,000	.0038		
35,000	.0060		
5,000		.0022	
40,000	.0092		
45,000	.0130		
50,000	.0175		
60,000	.0275		
70,000	.0490		
80,000	.0860		
90,000	.15		
100,000	.23		
101,200	.24		Ultimate strength. Sheared rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	19,765
Tensile strain on net section of plate	33,180
Compressive strain on bearing surface of rivets	48,890
Shearing strain on rivets	39,220

No. 327.—½" Wrought-iron Plate. Joint A A A



¾" steel rivets; 13/16" drilled holes.

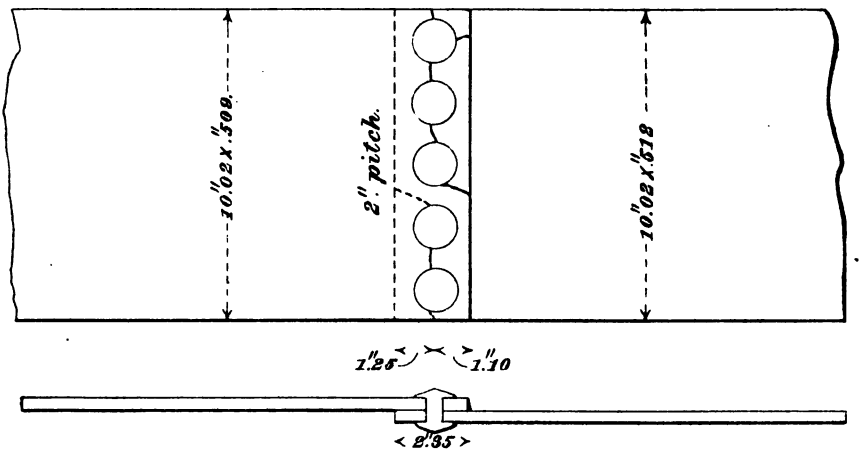
	Square inches.
Gross sectional area of upper plate	5.11
Net sectional area of upper plate	3.04
Bearing surface of rivets	2.06
Shearing area of rivets (".81 diameter)	2.58

Ultimate strength, 121,300 pounds.
Sheared four rivets and tore out upper plate at one end rivet.
Fractures started at rivet holes in upper plate.
Average elongation of rivet holes in upper plate, ".15.
Average elongation of rivet holes in lower plate, ".14.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	23,740
Tensile strain on net section of upper plate	39,900
Compressive strain on bearing surface of rivets	58,880
Shearing strain on rivets	47,020

No. 328.—½" Wrought Iron. Joint A A A . .



¾" steel rivets; 1 1/16" drilled holes.

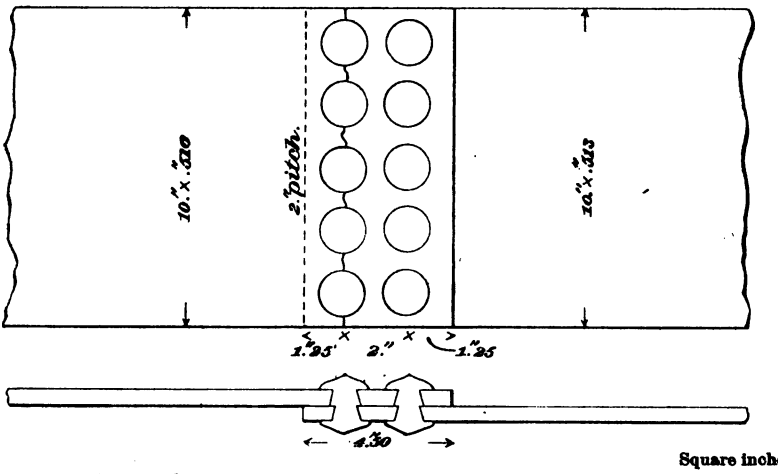
	Square inches.
Gross sectional area of upper plate	5.10
Net sectional area of upper plate	3.04
Bearing surface of rivets	2.06
Shearing area of rivets	2.58

Ultimate strength, 123,400 pounds.
Fractured plates opposite three rivets in upper plate and opposite two rivets in under plate.
Seam in upper plate 4" wide.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	24,200
Tensile strain on net section of upper plate	40,590
Compressive strain on bearing surface of rivets	59,900
Shearing strain on rivets	47,830

No. 329.—½″ Wrought-iron Plate. Joint C

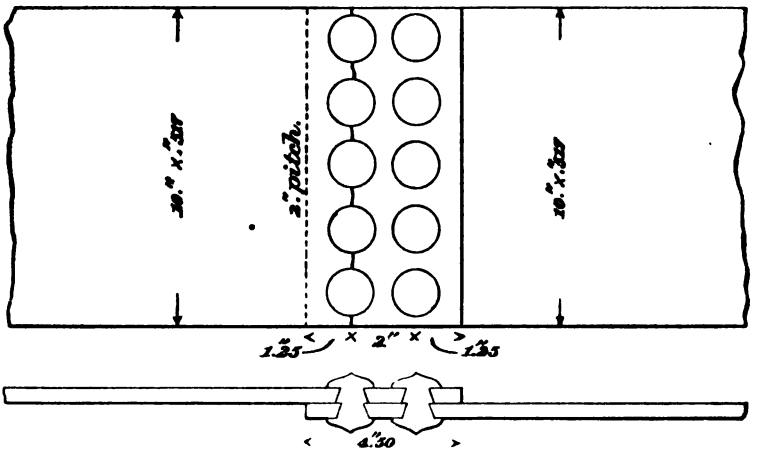


	Square inches.
Gross sectional area of upper plate	5.16
Net sectional area of upper plate	2.96
Bearing surface of rivets	2.20
Shearing area of rivets	5.19

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0015		
30,000	.0033		
35,000	.0042		
5,000		.0005	
40,000	.0055		
50,000	.0080		
5,000		.0018	
55,000	.0099		
60,000	.0116		
65,000	.0142		
70,000	.0170		
75,000	.0212		
80,000	.0250		
85,000	.0300		
90,000	.0348		
95,000	.0400		
100,000	.0470		
5,000		.0338	
131,200			Ultimate strength.

Fractured upper plate across line of rivet holes.

No. 635.—½″ Iron Plate. Joint C . .



$\frac{3}{4}$″ iron rivets, "Burden's best."
Punched holes: Punch, $\frac{13}{16}$″ diameter; die, $\frac{17}{64}$″ diameter.

	Square inches.
Gross sectional area of plate	5.17
Net sectional area of plate	2.97
Bearing surface of rivets	2.20
Shearing area of rivets	5.19

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0009		
20,000	.0015		
30,000	.0032		
35,000	.0045		
5,000		.0005	
40,000	.0055		
50,000	.0081		
5,000		.0020	
55,000	.0100		
60,000	.0120		
65,000	.0141		
70,000	.0175		
75,000	.0220		
80,000	.0260		
85,000	.0312		
90,000	.0370		
95,000	.0435		
100,000	.0518		
5,000		.0398	
127,480			Ultimate strength.
115,000			At time of fracture.

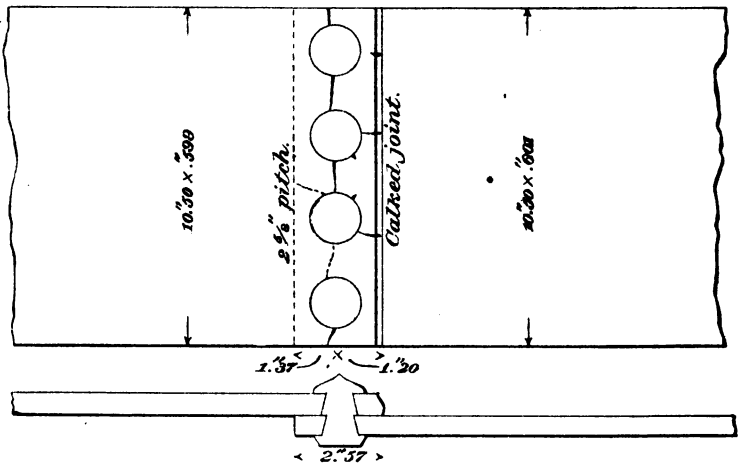
Fractured upper plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	24,660
Tensile strain on net section of plate	42,920
Compressive strain on bearing surface of rivets	57,950
Shearing strain on rivets	24,560

SINGLE AND DOUBLE RIVETED LAP JOINTS, ¼″ IRON PLATE.

No. 730.—⅝″ IRON PLATE. SET A.



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	6.29
Net sectional area of upper plate	3.63
Bearing surface of rivets	2.65
Shearing area of rivets	3.55

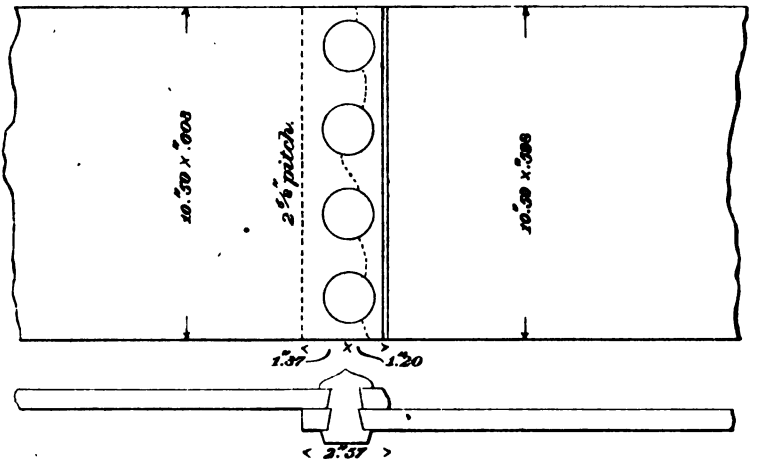
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0001		
20,000	.0009		
30,000	.0021		
40,000	.0038		
50,000	.0065		
55,000	.0080		
60,000	.0120		
65,000	.0148		
70,000	.0180		
75,000	.0240		
80,000	.0540		
90,000	.09		
95,000			Snapping sound heard.
100,000	.13		
110,000	.19		
120,000	.27		
125,900			Ultimate strength.

Fractured upper plate across three rivet holes; lower plate fractured across two rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	20,020
Tensile strain on net section of upper plate	34,680
Compressive strain on bearing surface of rivets	47,510
Shearing strain on rivets	35,460

No. 731.—⅝″ Iron Plate. Set A . .



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	6.28
Net sectional area of under plate	3.62
Bearing surface of rivets	2.65
Shearing area of rivets	3.55

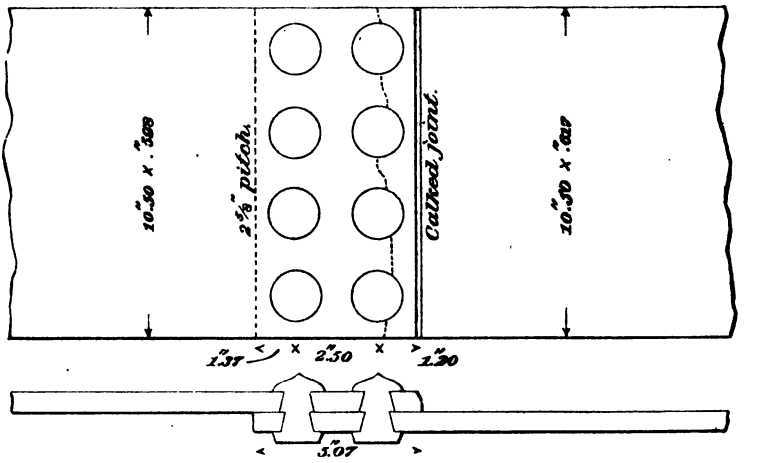
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0010		
30,000	.0021		
40,000	.0040		
45,000	.0055		
50,000	.0078		
55,000	.0105		
60,000	.0140		
65,000	.0180		
70,000	.0250		
75,000	.0520		
80,000	.0708		
90,000	.09		
100,000	.15		
110,000	.22		
120,000	.29		
124,000			Ultimate strength.

Fractured under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	19,750
Tensile strain on net section of under plate	34,230
Compressive strain on bearing surface of rivets	46,790
Shearing strain on rivets	34,930

No. 732.—$\frac{5}{8}$″ Iron Plate. Set C.



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	6.48
Net sectional area of under plate	3.74
Bearing surface of rivets	5.48
Shearing area of rivets	7.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0011		
30,000	.0025		
40,000	.0040		
50,000	.0060		
55,000	.0072		
60,000	.0091		
65,000	.0112		
70,000	.0135		
75,000	.0160		
80,000	.0190		
85,000	.0220		
90,000	.0251		
95,000	.0290		
100,000	.0320		
105,000	.0361		
110,000	.0405		
120,000	.08		
140,000	.10		
150,000	.14		
160 000	.17		
163,000			Ultimate strength.

Fractured under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	25,150
Tensile strain on net section of under plate	43,580
Compressive strain on bearing surface of rivets	29,740
Shearing strain on rivets	22,990

No. 733.—$\frac{5}{8}$″ Iron Plate. Set C . .

Same style of joint as No. 732.
Upper plate, 10″.50×″.613.
Under plate, 10″.50×″.604.
1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	6.34
Net sectional area of under plate	3.66
Bearing surface of rivets	5.36
Shearing area of rivets	7.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	.0018		
30,000	.0030		
40,000	.0048		
50,000	.0075		
55,000	.0093		
60,000	.0113		
65,000	.0140		
70,000	.0168		
80,000	.0225		
90,000	.0298		
100,000	.0375		
110,000	.0470		
120,000	.06		
130,000	.07		
140,000	.08		
150,000	.10		
160,000	.14		
167,800			Ultimate strength.

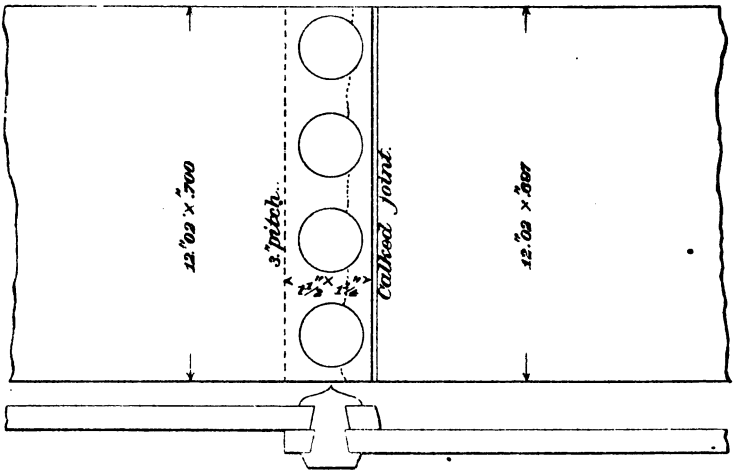
Fractured under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	26,470
Tensile strain on net section of under plate	45,450
Compressive strain on bearing surface of rivets	31,310
Shearing strain on rivets	23,670

SINGLE AND DOUBLE RIVETED LAP JOINTS, ¼" IRON PLATE.

No. 722.—¾" Iron Plate. Set A.



1⅛" iron rivets, hand-driven.
Punched holes: Punch, 1 3/16" diameter; die, 1 3/32" diameter.

	Square inches.
Gross sectional area of under plate	8.38
Net sectional area of under plate	4.93
Bearing surface of rivets	3.44
Shearing area of rivets	4.43

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0010		
30,000	.0020		
40,000	.0032		
50,000	.0065		
55,000	.0088		
60,000	.0111		
65,000	.0141		
70,000	.0168		
75,000	.0195		
80,000	.0230		
85,000	.0400		Joint opened perceptibly.
90,000	.0480		
100,000	.07		
110,000	.10		Joint open ".03.
120,000	.14		
130,000	.19		
140,000	.29		
144,400			Ultimate strength.

Fractured the under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	17,230
Tensile strain on net section of under plate	29,290
Compressive strain on bearing surface of rivets	41,980
Shearing strain on rivets	32,600

No. 723.—¾″ IRON PLATE. SET A . .

Duplicate of A . No. 722.
Upper plate, 12″.02×″.699.
Under plate, 12″.02×″.697.
1⅛″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{3}{16}$″ diameter; die, $1\frac{9}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	8.38
Net sectional area of under plate	4.93
Bearing surface of rivets	8.44
Shearing area of rivets	4.43

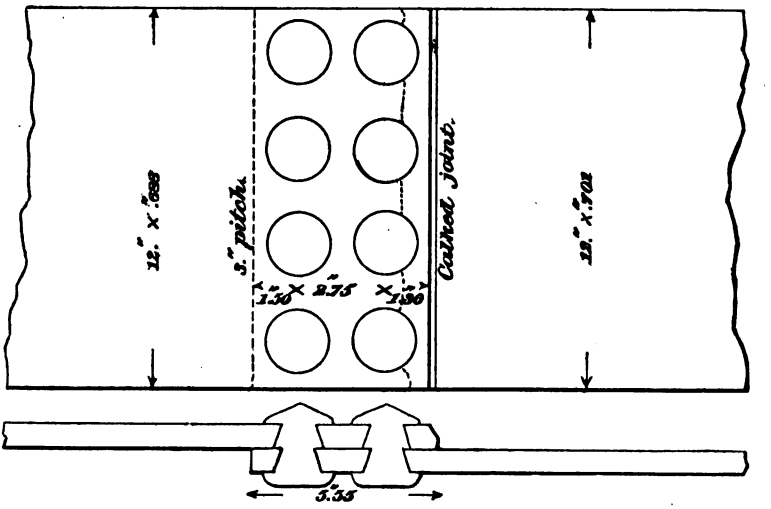
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0008		
30,000	.0012		
40,000	.0021		
45,000	.0028		
50,000	.0041		
55,000	.0061		
60,000	.0085		
65,000	.0120		
70,000	.0148		
75,000	.0183		
80,000	.0210		
85,000	.0271		
90,000	.0370		
95,000	.0500		
100,000	.062		
110,000	.07		
120,000	.08		
125,000			Sharp sound heard.
130,000	.16		
140,000	.21		
150,000	.33		
151,500			Ultimate strength.

Fractured the under plate across line of rivet holes.
Snapping sounds heard at intervals after load on joint reached 125,000 pounds.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	18,080
Tensile strain on net section of under plate	30,730
Compressive strain on bearing surface of rivets	44,040
Shearing strain on rivets	34,200

No. 724.—$\frac{3}{4}$″ IRON PLATE. SET C.



$1\frac{1}{8}$″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{3}{16}$″ diameter; die, $1\frac{9}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	8.41
Net sectional area of under plate	4.95
Bearing surface of rivets	6.92
Shearing area of rivets	8.86

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0009		
30,000	.0018		
40,000	.0030		
50,000	.0045		
60,000	.0068		
70,000	.0098		
80,000	.0145		
85,000	.0160		
90,000	.0190		
95,000	.0230		
100,000	.0255		Sharp snapping sounds heard.
105,000	.0289		
110,000	.0320		
120,000	.08+		Joint open ".02.
130,000	.04		
140,000	.05		
150,000	.06		
162,000	.07		
170,000	.10		
180,000	.13		
200,000	.23		
207,900			Ultimate strength.

Fractured under plate across line of rivet holes.
After test upper plate found bent to an angle of 10°.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	24,720
Tensile strain on net section of under plate	42,000
Compressive strain on bearing surface of rivets	30,040
Shearing strain on rivets	23,460

No. 725.—$\frac{3}{4}$″ Iron Plate. Set C . .

Duplicate of C . No. 724.
Upper plate, 12″×″.393.
Under plate, 12″×″.681.
$1\frac{1}{8}$″ iron rivets, hand-driven.
Punched holes: Punch, ″$1\frac{3}{16}$ diameter; die, ″$1\frac{9}{32}$ diameter.

	Square inches.
Gross sectional area of under plate	8.17
Net sectional area of under plate	4.81
Bearing surface of rivets	6.72
Shearing area of rivets	8.86

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0001		
20,000	.0008		
30,000	.0012		
40,000	.0020		
50,000	.0030		
60,000	.0050		
70,000	.0068		
80,000	.0092		
90,000	.0135		
95,000	.0160		
100,000	.0185		
105,000	.0210		
110,000	.0240		
120,000	.0308		Snapping sounds heard.
130,000	.0380		
140,000	.0465		
150,000	.0575		
160,000	.07		
170,000	.09		
180,000	.11		
190,000	.15		
200,000	.18		
210,000	.22		
211,400			Ultimate strength.

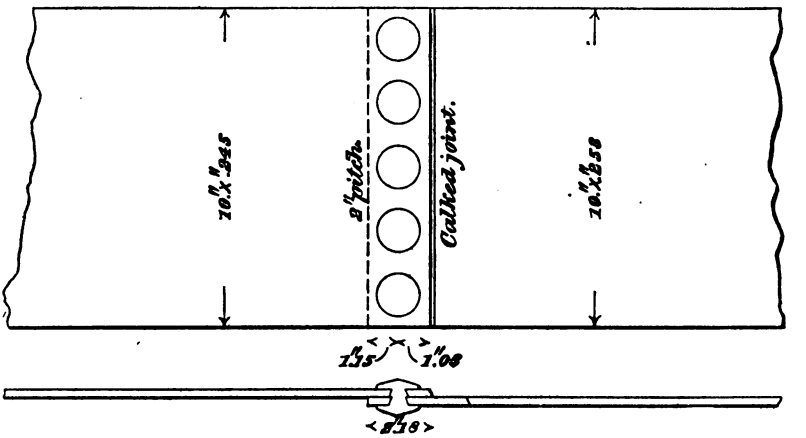
Fractured under plate across line of rivet holes.

Maximum loads on joint.

	Pounds per sq inch.
Tensile strain on gross section of under plate	25,870
Tensile strain on net section of under plate	43,950
Compressive strain on bearing surface of rivets	31,460
Shearing strain on rivets	23,860

SINGLE-RIVETED LAP JOINTS, ¼″ STEEL PLATE.

No. 426.—¼″ STEEL PLATE. JOINT A.



⅝″ iron rivets, "Burden's best," machine-driven.
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches
Gross sectional area of upper plate	2.45
Net sectional area of upper plate	1.57
Bearing surface of rivets	.882
Shearing area of rivets (".70 diameter)	1.92

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
8,000	.0004		
10,000	.0011		
15,000	.0022		
20,000	.0035		
5,000		.0002	
25,000	.0051		
30,000	.0067		
35,000	.0090		
5,000		.0031	
38,000	.0108		
40,000	.0122		
42,000	.0136		
44,000	.0152		
46,000	.0171		
48,000	.0198		
50,000	.0234		Calking shows decided movement of plates; also plates slightly bent.
5,000		.0125	
52,000	.0310		Continued bending of plates.
54,000	.0365		Scale starts off upper plate along a line just touching rivet heads.
56,000	.0434		
58,000	.0491		
60,000	.0578		
5,000		.0432	
62,000	.0661		
64,000	.0758		Calking opened about ".06.
66,000	.0911		
68,000	.1102		
70,000	.1362		
72,000	.1790		
72,750	.2260		Ultimate strength.

Sheared the rivets; all rivets appeared to shear at same time. Fractured slightly two rivets under upper heads. Fractured all the rivets

under the lower heads. No fractures started in the steel plates. Average elongation of holes in the plate, ".07.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	29,690
Tensile strain on net section of upper plate	46,340
Compressive strain on bearing surface of rivets	82,480
Shearing strain on rivets	37,890

No. 427.—¼" Steel Plate. Joint A . .

Same style of joint as No. 426.
Upper plate, 10" × ".247.
Under plate, 10" × ".247.
⅝" iron rivets, "Burden's best," machine-driven.
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.47
Net sectional area of plate	1.58
Bearing surface of rivets	.889
Shearing area of rivets (".70 diameter)	1.92

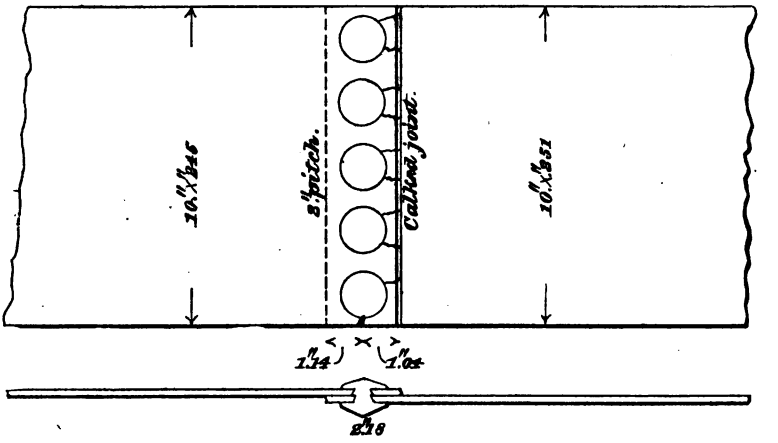
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
8,000	0.		
10,000	0.		
15,000	.0001		
20,000	.0008		
5,000		.0009	
5,000	0.		New gaugings began.
20,000	.0002		
25,000	.0010		
30,000	.0023		
35,000	.0040		
5,000		.0020	
38,000	.0052		
40,000	.0063		
42,000	.0075		
44,000	.0089		
46,000	.0099		
48,000	.0112		
50,000	.0159		
5,000		.0090	
52,000	.0210		
54,000	.0258		
56,000	.0312		
58,000	.0370		
60,000	.0452		
5,000		.0352	Calked joint opened about ".03.
62,000	.0540		Scale has started on two rivet heads.
64,000	.0620		
66,000	.0760		
68,000	.0890		
70,000	.1070		
72,700	.1660		Ultimate strength. Sheared rivets.

After the ultimate load was passed and the pressure running down gradually the rivets sheared not simultaneously, as appeared to be the case with A . , but one rivet snapped first, quickly followed by the second and third; the two remaining rivets sounded as one when they parted.

Maximum loads on joints.

	Pounds per sq. inch.
Tensile strain on gross section of plate	29,430
Tensile strain on net section of plate	46,010
Compressive strain on bearing surface of rivets	81,780
Shearing strain on rivets	37,860

No. 436.—¼″ Steel Plate. Joint A A.



⅝″ steel rivets, machine driven.
Punched holes: Punch, ″.69 diameter; die, ″.75 diameter.

	Square inches.
Gross sectional area of plate	2.45
Net sectional area of plate	1.57
Bearing surface of rivets	.882
Shearing area of rivets (″.70 diameter)	1.92

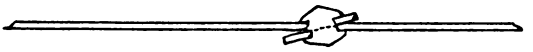
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000			The joint was not caulked tight; slightly open at the commencement of the test.
10,000	.0007		
15,000	.0017		
20,000	.0031		
25,000	.0044		
30,000	.0067		
35,000	.0092		
5,000		.0030	
38,000	.0108		
40,000	.0118		
42,000	.0130		
44,000	.0142		
46,000	.0153		
48,000	.0171		
50,000	.0187		Slight change in calking of joint is perceptible.
5,000		.0077	
52,000	.0207		
54,000	.0237		
56,000	.0263		
58,000	.0300		
60,000	.0332		Joint opened about ″.03.
62,000	.0362		
64,000	.0411		
66,000	.0452		Joint opened about ″.05.
68,000	.0521		
70,000	.0614		
72,000	.0690		
74,000	.0792		
76,000	.0882		
78,000	.1070		
80,000	.123		
94,600			Ultimate strength.

Ultimate failure occurred by shearing the upper plate through the metal, as shown by the lines in the sketch. The first fracture which

appeared in sight was at the end section at *A*. Holes in the under plate elongated about $\frac{3}{16}$" each.

Appearance of fractures: Silvery scale not disturbed on the body of the specimen.

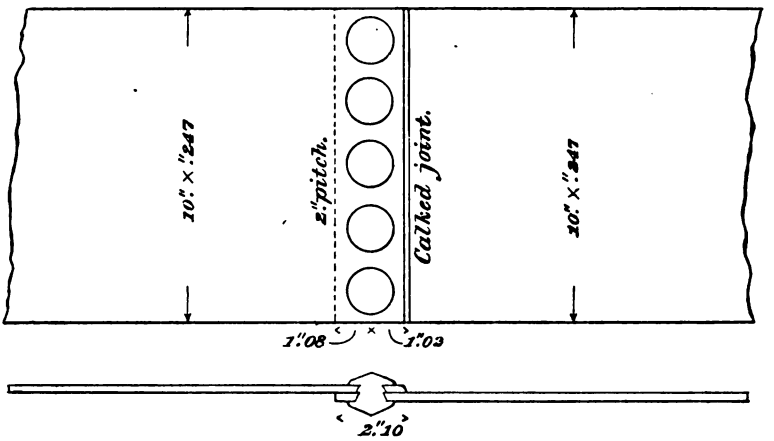
Lap ends of plate bent about 12°.

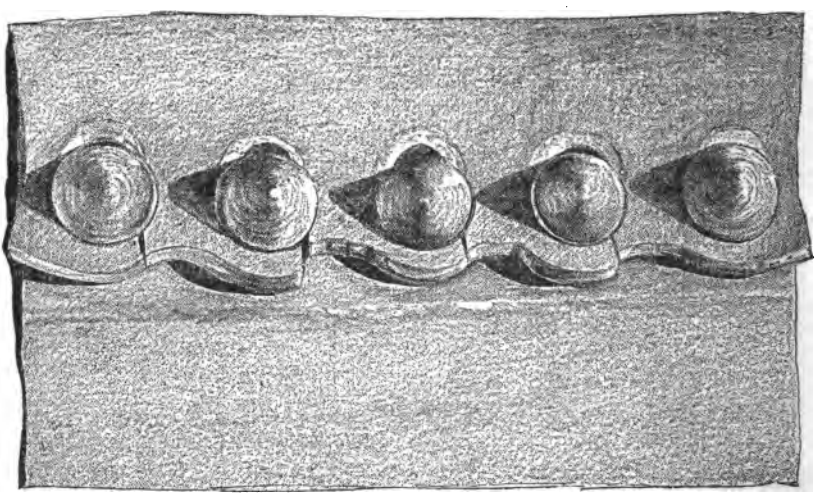


Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	38,610
Tensile strain on net section of plate	60,250
Compressive strain on bearing surface of rivets	107,260
Shearing strain on rivets	49,270

No. 437.—$\frac{1}{4}$" Steel Plate. Joint A A . .





$\frac{5}{8}$" steel rivets.

Punched holes: Punch, ".69 diameter; die, ".75 diameter.

	Square inches.
Gross sectional area of plate	2.47
Net sectional area of plate	1.58
Bearing surface of rivets	.889
Shearing area of rivets (".70 diameter)	1.92

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0010	.....	
15,000	.0025	.....	
20,000	.0040	.....	
25,000	.0061	.....	
30,000	.0082	.....	
35,000	.0108	.....	
5,000	.....	.0035	
38,000	.0120	.....	Calking opened slightly in places.
40,000	.0130	.....	
42,000	.0140	.....	
44,000	.0150	.....	Joint opened ".01.
46,000	.0165	.....	
48,000	.0178	.....	
50,000	.0191	.....	Joint open about ".02.
52,000	.0211	.....	
54,000	.0235	.....	
56,000	.0260	.....	
58,000	.0295	.....	
60,000	.0329	.....	Joint open ".03.
62,000	.0360	.....	
64,000	.0402	.....	Scale started on rivet heads.
66,000	.0445	.....	
68,000	.0518	.....	Joint open ".04.
70,000	.0599	.....	
74,000	.0755	.....	
78,000	.0950	.....	
80,000	.1095	.....	
90,000	.2470	.....	
93,600	.3770	.....	Ultimate strength.

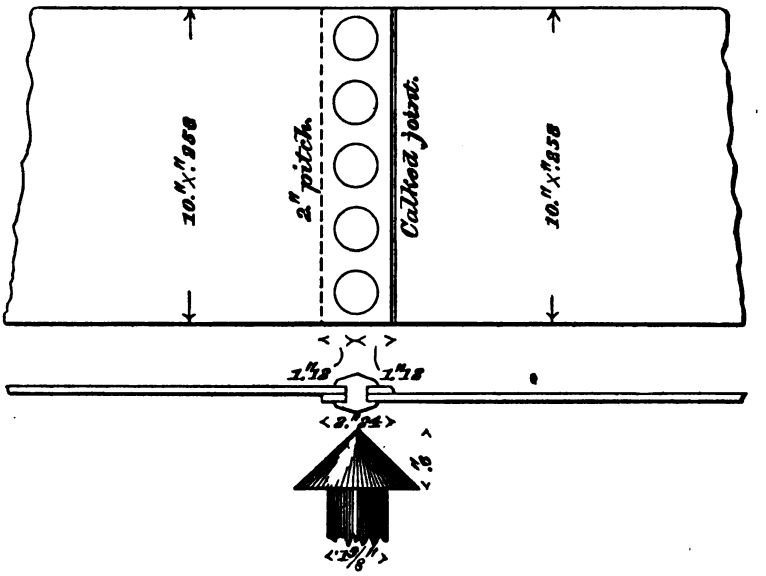
Joint failed similar to A A'. by shearing plate, fractures beginning at the rivet holes.

Test discontinued before the fractures were all developed, the first fracture appearing at the second rivet from side of plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	37,895
Tensile strain on net section of plate	59,240
Compressive strain on bearing surface of rivets	105,290
Shearing strain on rivets	48,750

No. 428.—¼″ Steel Plate. Joint C.



⅝″ iron rivets, "Burden's best," machine-drawn.
Drilled holes, ".69 diameter.

	Square inches.
Gross sectional area of plate	2.53
Net sectional area of plate	1.66
Bearing surface of rivets	.873
Shearing area of rivets (".69 diameter)	1.87

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
8,000	.0006		
10,000	.0010		
15,000	.0020		
20,000	.0040		
5,000		.0006	
25,000	.0057		
30,000	.0089		
32,000	.0097		
34,000	.0103		
35,000	.0109		
5,000		.0031	
36,000	.0113		
38,000	.0122		
40,000	.0136		Scale started on two rivet heads; calking opened slightly.
42,000	.0149		
44,000	.0161		
46,000	.0179		
48,000	.0223		Calked joint opened about ".02.
50,000	.0299		
5,000		.0161	
52,000	.0361		
54,000	.0430		
56,000	.0520		
58,000	.0620		
60,000	.0730		
62,000	.0910		
64,000	.1070		
66,000	.1330		
67,980	.2090		Ultimate strength.

Joint failed by shearing rivets and tearing off rivet heads.
Elongation of holes after fracture about ".07.

REMARKS.—The form of the rivet heads appears to be such as to develop weakness under the heads; the conical head being weak and easily bent at the edge, brings a strain tending to tear off the head, which is illustrated by the failure specimens A . A . . and C .

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	26,870
Tensile strain on net section of plate	40,950
Compressive strain on bearing surface of rivets	77,870
Shearing strain on rivets	36,350

No. 429.—¼" STEEL PLATE. JOINT C . .

Same style of joint as No. 428.
Upper plate, 10" × ".248.
Under plate, 10" × ".248.
⅝" iron rivets, "Burden's best," machine-drawn.
Drilled holes, ".69 diameter.

	Square inches.
Gross sectional area of plate	2.48
Net sectional area of plate	1.62
Bearing surface of rivets	.856
Shearing area of rivets (".69 diameter)	1.87

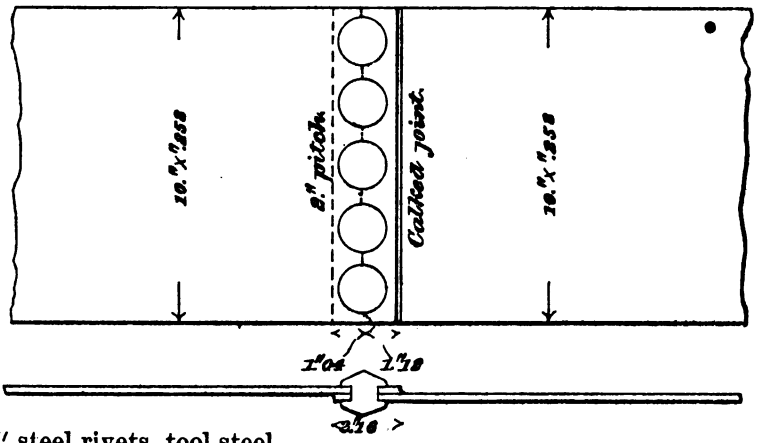
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
8,000	.0008	.....	
10,000	.0015	.....	
15,000	.0027	.....	
20,000	.0045	.....	
5,000	.....	.0006	
25,000	.0062	.....	
30,000	.0087	.....	
35,000	.0116	.....	
5,000	.....	.0033	
38,000	.0136	.....	
40,000	.0155	.....	
42,000	.0172	.....	
44,000	.0195	.....	
46,000	.0227	.....	
48,000	.0276	.....	
50,000	.0327	.....	
52,000	.0390	.....	
54,000	.0450	.....	
56,000	.0530	.....	
58,000	.0620	.....	
60,000	.0720	.....	
68,650	.1860	.....	Ultimate strength.

Failed by shearing the rivets.
Fractures started under rivet heads.

Maximum loads on joint.

	Pounds per sq. inch
Tensile strain on gross section of plate	27,680
Tensile strain on net section of plate	42,370
Compressive strain on bearing surface of rivets	80,200
Shearing strain on rivets	36,710

No. 438.—¼″ Steel Plate. Joint C C



⅝″ steel rivets, tool-steel.
Drilled holes, ″.69 diameter.

	Square inches.
Gross sectional area of plate	2.53
Net sectional area of plate	1.66
Bearing surface of rivets	.873
Shearing area of rivets (″.69 diameter)	1.87

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000			
10,000	.0010		
15,000	.0020		
20,000	.0035		
25,000	.0049		
30,000	.0068		
35,000	.0091		
5,000		.0040	
38,000	.0110		Perceptible opening of joint.
40,000	.0120		
42,000	.0130		
44,000	.0145		
46,000	.0160		
48,000	.0170		Joint opened ″.01
50,000	.0190		
5,000		.0098	
52,000	.0210		
54,000	.0230		
56,000	.0258		
58,000	.0290		Joint open ″.02.
60,000	.0320		
62,000	.0358		Joint open ″.03.
64,000	.0390		
66,000	.0430		Joint open ″.04.
68,000	.0475		
70,000	.0522		
74,000	.0640		Joint open ″.05.
78,000	.0800		
80,000	.0930		Joint open ″.06 to ″.07.
90,000	.1910		
96,000	.3270		
104,900			Ultimate strength.

Tore under plate through line of rivets, fracture first making its appearance at second rivet hole. Before the ultimate strain was reached the under plate had stretched about the holes to such an extent that some of the holes were in sight beyond the rivet heads. After fracture the average elongation of holes in the fractured plate was ″.55. Fracture silky and the metal well drawn down. One rivet was weakened by the shearing strain.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	41,460
Tensile strain on net section of plate	63,190
Compressive strain on bearing section of rivets	120,160
Shearing strain on rivets	56,100

No. 439.—¼″ STEEL PLATE. JOINT C . C .

Same style of joint as No. 438.
Upper plate, 10″ × ″.248.
Under plate, 10″ × ″.245.
⅝″ steel rivets, tool-steel.
Drilled holes, ″.69 diameter.

	Square inches.
Gross sectional area of plate	2.45
Net sectional area of plate	1.60
Bearing surface of rivets	.845
Shearing area of rivets (″.69 diameter)	1.87

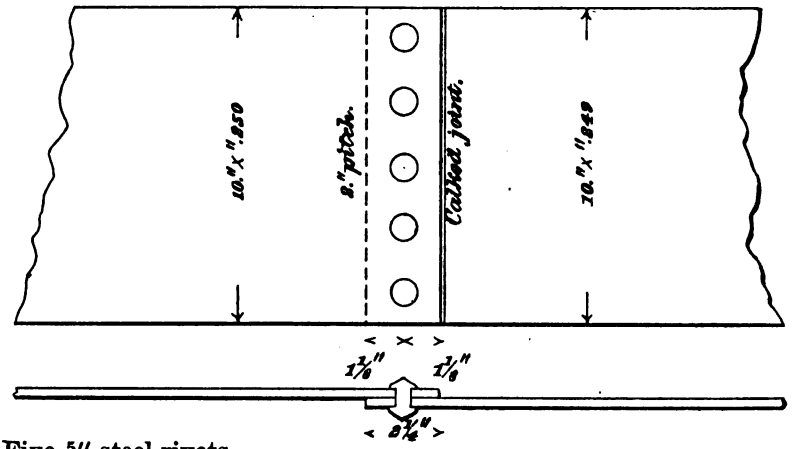
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000			
10,000	.0012		
15,000	.0022		
20,000	.0037		
25,000	.0052		
30,000	.0072		
35,000	.0101		
5,000		.0032	
38,000	.0114		
40,000	.0128		
42,000	.0142		Perceptible starting of the calked joint.
45,000	.0163		
48,000	.0192		
50,000	.0214		Joint opened about ″.00½.
5,000		.0103	Joint closes where strains are released.
52,000	.0242		Joint open ″.01.
55,000	.0300		
58,000	.0361		
60,000	.0402		
62,000	.0450		
64,000	.0492		
66,000	.0552		Joint open ″.05.
68,000	.0622		Joint open ″.06.
70,000	.0713		
75,000	.1002		
80,000	.1462		
90,000	.3510		
98,100			Ultimate strength.

Fractured through the under plate same as C C . Before the ultimate load was reached the holes in the under plate had elongated so as to appear beyond the rivet heads. After fracture, average elongation of holes in fractured plate ″.53; metal well drawn down. Total width of steel reduced about ″.06, the joint ends puckered, presenting wavy lines. The holes in the upper plate elongated about ″.28 each. Opposite one rivet the metal began to fracture from the end of the plate. When final fracture occurred the metal gave way, first at the inside sections. The rivets were weakened and indented about ″.04 by the shearing strain.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	40,040
Tensile strain on net section of plate	61,310
Compressive strain on bearing surface of rivets	116,090
Shearing strain on rivet	52,460

No. 49.—¼″ Steel Plate. Joint C C C.



Five ⅝″ steel rivets.
Drilled holes, ″.69 diameter.

	Square inches.
Gross sectional area of under plate	2.49
Net sectional area of under plate	1.63
Bearing surface of rivets	8.56
Shearing area of rivets	1.57

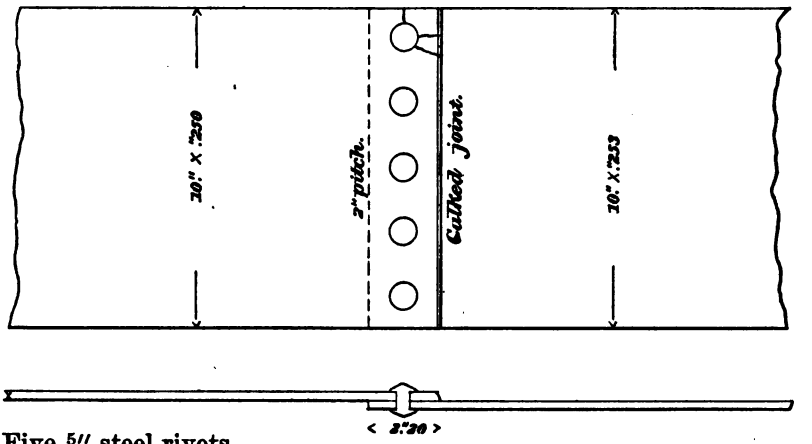
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
15,000	.0910		
20,000	.0020		
25,000	.0035		
30,000	.0050		
35,000	.0080		
5,000		.0035	
40,000	.0110		
45,000	.0143		
50,000	.0182		
52,000	.0198		
54,000	.0218		
56,000	.0245		
58,000	.0270		
60,000	.0306		
62,000	.0345		Joint started perceptibly.
64,000	.0465		Joint open ″.01.
66,000	.0530		
68,000	.0585		Joint open ″.03.
70,000	.0688		Joint open ″.04.
72,000	.0768		
74,000	.0870		Joint open ″.05.
76,000	.0960		
78,000	.1090		
80,000	.1218		
98,100			Ultimate strength. Sheared rivets.

Average elongation of holes, ″.18.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	39,400
Tensile strain on net section of plate	60,184
Compressive strain on bearing surface of rivets	114,603
Shearing strain on rivets	52,742

No. 50.—¼″ Steel Plate. Joint CCC . .



Five ⅝″ steel rivets.
Drilled holes, ″.69 diameter.

	Square inches.
Gross sectional area of upper plate	2.50
Net sectional area of upper plate	1.64
Bearing surface of rivets	.859
Shearing area of rivets	1.86

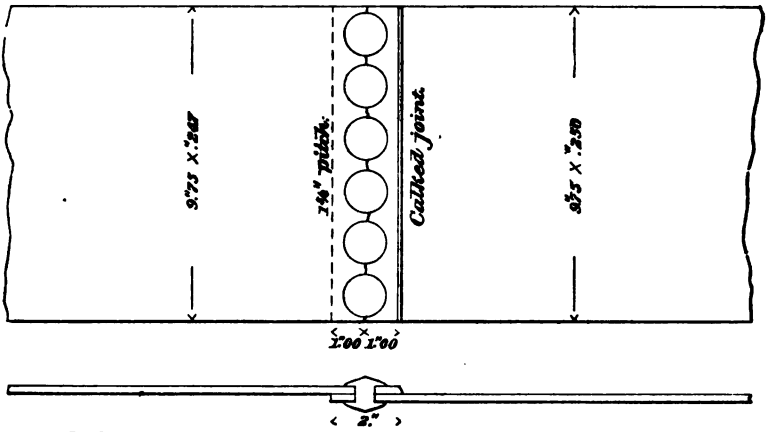
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0030		
30,000	.0069		
35,000	.0090		
5,000		.0040	
40,000	.0125		
45,000	.0151		
50,000	.0188		
52,000	.0210		
54,000	.0235		Joint started perceptibly.
56,000	.0280		
58,000	.0350		Joint open ″.01.
60,000	.0395		
62,000	.0452		
64,000	.0508		Joint open ″.02.
66,000	.0568		
68,000	.0640		Joint open ″.03.
70,000	.0710		
72,000	.0790		Joint open ″.04.
74,000	.0880		
76,000	.0988		
78,000	.1112		Joint open ″.05.
80,000	.1275		
94,200			Ultimate strength. Sheared four rivets. Tore out plate at end rivet.

Elongation of inside holes, ″.12 each.
Elongation of end hole, ″.26.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	37,680
Tensile strain on net section of plate	57,439
Compressive strain on bearing surface of rivets	109,650
Shearing strain on rivets	50,645

No. 430.—¼″ Steel Plate. Joint E.



⅝″ steel rivets.
Drilled holes, ″.69 diameter.

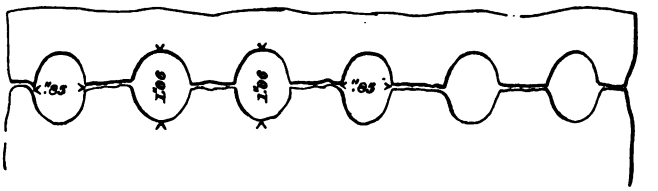
	Square inches.
Gross sectional area of plate	2.44
Net sectional area of plate	1.40
Bearing surface of rivets	1.04
Shearing area of rivets (″.69 diameter)	2.24

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
8,000	.0007	.....	
10,000	.0013	.....	
15,000	.0030	.....	
20,000	.0045	.....	
5,000	.....	.0010	
25,000	.0064	.....	
30,000	.0085	.....	
35,000	.0110	.....	
5,000	.....	.0033	
40,000	.0135	.....	
42,000	.0147	.....	
44,000	.0160	.....	
46,000	.0173	.....	
48,000	.0187	.....	
50,000	.0205	.....	Calked joint slightly started.
52,000	.0223	.....	
54,000	.0245	.....	
56,000	.0265	.....	
58,000	.0295	.....	
60,000	.0321	.....	
5,000	.....	.0173	
10,000	.0012	.....	
15,000	.0022	.....	
20,000	.0037	.....	
25,000	.0052	.....	
30,000	.0067	.....	
35,000	.0067	.....	
40,000	.0082	.....	
50,000	.0110	.....	
60,000	.0142	.....	
62,000	.0332	.....	
64,000	.0364	.....	
66,000	.0395	.....	
68,000	.0431	.....	
70,000	.0460	.....	
72,000	.0500	.....	
74,000	.0540	.....	
76,000	.0595	.....	
78,000	.0681	.....	
80,000	.0745	.....	
82,000	.0833	.....	
84,000	.0947	.....	
93,600	.....	.....	Ultimate strength.

Failed by fracturing the under plate through rivet holes.
Silky fractures slightly lamellar, metal well drawn down.
Scale started on rivet heads; otherwise they appear undisturbed.
After the test the rivets were loose in the plate not fractured.
Fracture began at one edge and in first section between rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of lower plate	38,360
Tensile strain on net section of lower plate	66,860
Compressive strain on bearing surface of rivets	90,000
Shearing strain on rivets	



Sketch, drawn one-third size, showing shape of rivet holes in fractured plate.

No. 431.—¼″ Steel Plate. Joint E . .

Same style of joint as No. 430.
Upper plate, 9″.75 × ″.250.
Under plate, 9.″75 × .″250.
⅝″ steel rivets.
Drilled holes, ″.69 diameter.

	Square inches.
Gross sectional area of plate	2.44
Net sectional area of plate	1.40
Bearing surface of rivets	1.04
Shearing area of rivets (″.69 diameter)	2.24

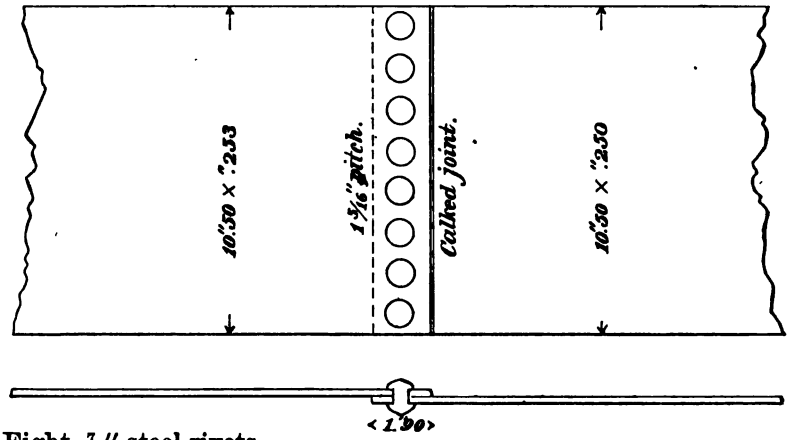
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0004	.....	
15,000	.0010	.....	
20,000	.0018	.....	
25,000	.0031	.....	
30,000	.0045	.....	
35,000	.0065	.....	
5,000	.....	.0025	
40,000	.0091	.....	
42,000	.0103	.....	
44,000	.0114	.....	
46,000	.0130	.....	
48,000	.0145	.....	
50,000	.0164	.....	
52,000	.0183	.....	
54,000	.0205	.....	
56,000	.0233	.....	
58,000	.0256	.....	
60,000	.0285	.....	
5,000	.....	.0180	Calked joint slipped but not opened.
62,000	.0311	.....	
64,000	.0343	.....	
66,000	.0374	.....	
68,000	.0405	.....	
70,000	.0447	.....	
72,000	.0493	.....	Rivet heads scale off. Joint is about ″.03 open.
74,000	.0525	.....	
76,000	.0583	.....	
78,000	.0673	.....	
80,000	.0860	.....	
98,000	.....	.....	Ultimate strength.

Fractured under plate through line of rivet holes same as E. The upper plate drew down in total width about ".10, causing the joint to pucker. Fine silky fractures, the metal well drawn down. Fracture began on one side, then reaching across the plate, beginning the fracture on the opposite side as it stood in the testing machine from the fracture of E.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	40,160
Tensile strain on net section of plate	70,000
Compressive strain on bearing surface of rivets	94,230
Shearing strain on rivets	

No. 47.—¼" STEEL PLATE. JOINT H.



Eight $\frac{7}{16}$" steel rivets.
Drilled holes, ".50 diameter.

	Square inches.
Gross sectional area of upper plate	2.66
Net sectional area of upper plate	1.64
Bearing surface of rivets	1.01
Shearing area of rivets	1.572

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
15,000	.0020		
20,000	.0028		
30,000	.0050		
35,000	.0070		
5,000		.0025	
40,000	.0095		
42,000	.0108		
44,000	.0120		
46,000	.0133		
48,000	.0150		
50,000	.0170		Scale starts on rivet heads.
5,000		.0075	
52,000	.0195		
54,000	.0220		
56,000	.0249		Joint started perceptibly.
58,000	.0270		
60,000	.0300		

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
62,000	.0320	.....	Joint open ".01.
64,000	.0350	.....	
66,000	.0380	.....	
68,000	.0420	.....	
70,000	.0461	.....	
72,000	.0500	.....	Joint open ".02.
74,000	.0549	.....	
76,000	.0590	.....	
78,000	.0652	.....	Joint open ".03.
80,000	.0695	.....	
82,000	.0758	.....	
84,000	.0830	.....	
86,000	.0890	.....	
88,000	.0972	.....	Joint open ".06.
90,000	.1072	.....	
92,000	.1250	.....	
96,600	.....	.....	Rapid stretching of plate.
102,400	.....	.....	Ultimate strength. Sheared rivets.

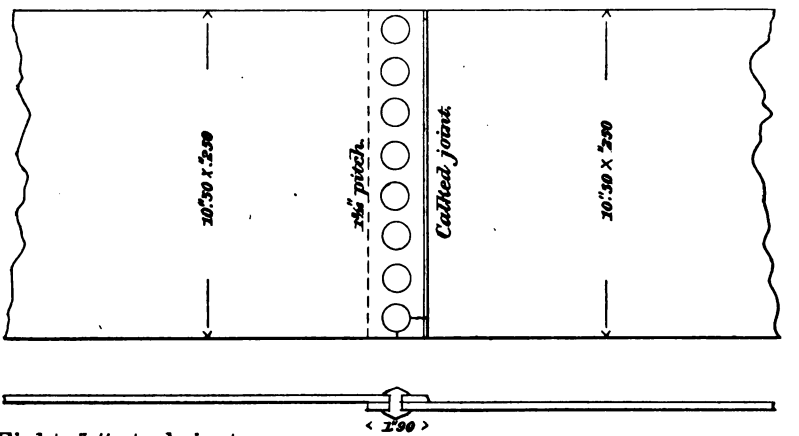
The inside of the upper plate showed very complete removal of scale. The outside of this plate the scale not removed partially. This behavior would naturally follow from the bending of the plate while under tensile stress, elongating the fibers on the convex side of the sheet more than the fibers on the concave side.

Average elongation of rivet holes, ".10.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	38,496
Tensile strain on net section of upper plate	62,440
Compressive strain on bearing surface of rivets	101,180
Shearing strain on rivets	65,220

No. 48.—¼" Steel Plate. Joint H . .



Eight $\frac{7}{16}$" steel rivets.
Drilled holes, ".50 diameter.

	Square inches.
Gross sectional area of plate	2.625
Net sectional area of plate	1.625
Bearing surface of rivets	1.00
Shearing area of rivets	1.57

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0009	.....	
20,000	.0030	.....	
30,000	.0060	.....	
35,000	.0081	.....	
5,000	.....	.0023	
40,000	.0110	.....	
45,000	.0140	.....	
48,000	.0162	.....	
50,000	.0180	.....	
52,000	.0200	.....	Scale started on rivet heads. Joint started perceptibly.
54,000	.0228	.....	
56,000	.0248	.....	
58,000	.0272	.....	
60,000	.0300	.....	
62,000	.0320	.....	
64,000	.0350	.....	
66,000	.0378	.....	
68,000	.0400	.....	Joint open ".01.
70,000	.0440	.....	
72,000	.0478	.....	
74,000	.0521	.....	
76,000	.0565	.....	
78,000	.0610	.....	Joint open ".02.
80,000	.0670	.....	
82,000	.0722	.....	Joint open ".03.
84,000	.0790	.....	
86,000	.0860	.....	
88,000	.0935	.....	
90,000	.1040	.....	Joint open ".06.
94,800	.....	.....	Ultimate strength. Sheared seven rivets and tore out plate at end rivet.

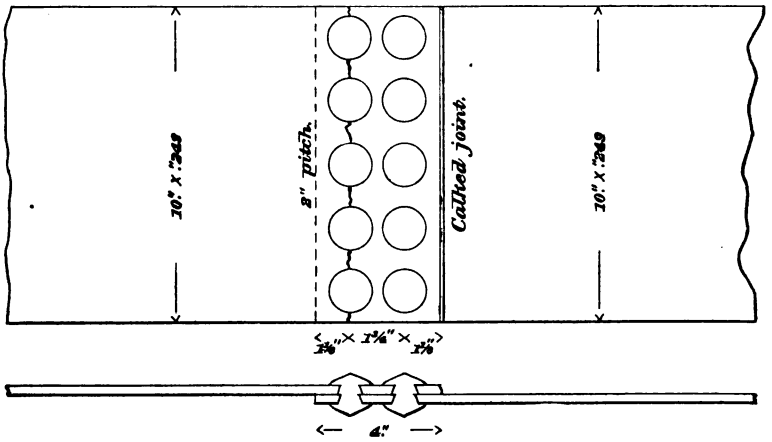
Average elongation of holes, ".07.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	36,114
Tensile strain on net section of plate	58,338
Compressive strain on bearing surface of rivets	94,880
Shearing strain on rivets	60,382

DOUBLE-RIVETED LAP JOINTS, ¼" STEEL PLATE.

No. 432.—¼" STEEL PLATE. JOINT F.



⅝" iron rivets, "Burden's best."
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.49
Net sectional area of plate	1.59
Bearing surface of rivets	1.79
Shearing area of rivets (".70 diameter)	3.85

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0012	.....	
15,000	.0026	.....	
20,000	.0041	.....	
5,000	.....	.0009	
25,000	.0055	.....	
30,000	.0071	.....	
35,000	.0089	.....	
5,000	.....	.0028	
40,000	.0110	.....	
42,000	.0118	.....	
44,000	.0125	.....	
46,000	.0133	.....	
48,000	.0142	.....	
50,000	.....	.....	Calked joint opened about ".01.
52,000	.0161	.....	
54,000	.0175	.....	
56,000	.0182	.....	
58,000	.0196	.....	
60,000	.0210	.....	
5,000	.....	.0116	
62,000	.0220	.....	
64,000	.0232	.....	
66,000	.0250	.....	Calked joint opened about ".03.
68,000	.0260	.....	
70,000	.0280	.....	
72,000	.0298	.....	
74,000	.0316	.....	
76,000	.0340	.....	
78,000	.0369	.....	
80,000	.0405	.....	Joint opened about ".04 to ".05.
82,000	.0440	.....	
84,000	.0500	.....	
86,000	.0610	.....	
97,800	.....	.....	Ultimate strength.

Fractured upper plate through line of rivet holes. Fractures began at the rivet holes weakening the whole plate at the same time, the bent and marked edge apparently not effecting the manner of fracture Fractures fine silky; metal well drawn down. The fractured plate had the die-side in.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	39,280
Tensile strain on net section of plate	61,510
Compressive strain on bearing surface of rivets	54,640
Shearing strain on rivets	25,400

No. 433.—¼" Steel Plate. Joint F..

Same style of joint as No. 432.
Upper plate, 10"×".248.
Under plate, 10"×".254.
⅝" iron rivets, "Burden's best."
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.54
Net sectional area of plate	1.63
Bearing surface of rivets	1.83
Shearing area of rivets (".70 diameter)	3.85

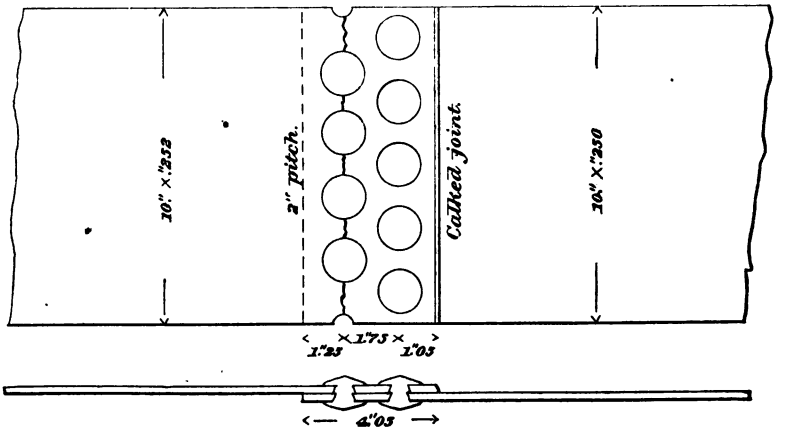
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0013	.....	
15,000	.0026	.....	
20,000	.0038	.....	
5,000	.....	.0008	
25,000	.0048	.....	
30,000	.0063	.....	
35,000	.0079	.....	
5,000	.....	.0018	
40,000	.0098	.....	
42,000	.0100	.....	
44,000	.0108	.....	
46,000	.0118	.....	
48,000	.0126	.....	
50,000	.0131	.....	
52,000	.0138	.....	
56,000	.0158	.....	
58,000	.0168	.....	Calked joint opened about ".01.
60,000	.0179	.....	
5,000	.....	.0070	
62,000	.0193	.....	
64,000	.0207	.....	
66,000	.0218	.....	
68,000	.0238	.....	
70,000	.0257	.....	
72,000	.0268	.....	
74,000	.0290	.....	
76,000	.0318	.....	
78,000	.0343	.....	
80,000	.0374	.....	
82,000	.0408	.....	
84,000	.0456	.....	
86,000	.0517	.....	
88,000	.0630	.....	
90,000	.0750	.....	
98,300	.....	.....	Ultimate strength.

Fractured lower plate across line of rivet holes; appearance of fracture, silky; metal well drawn down.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	38,700
Tensile strain on net section of plate	60,300
Compressive strain on bearing surface of rivets	53,715
Shearing strain on rivets	25,530

No. 434.—¼″ Steel Plate. Joint G.



⅝″ iron rivets, "Burden's best."
Punched holes: Punch, ".695 diameter; die, .752 diameter.

	Square inches.
Gross sectional area of plate	2.55
Net sectional area of plate	1.61
Bearing surface of rivets	1.63
Shearing area of rivets (".70 diameter)	3.46

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0014	.....	
15,000	.0027	.....	
20,000	.0039	.....	
5,000	.....	.0009	
25,000	.0054	.....	
30,000	.0071	.....	
35,000	.0091	.....	
5,000	.....	.0031	
40,000	.0117	.....	
42,000	.0127	.....	
44,000	.0135	.....	
46,000	.0149	.....	
48,000	.0159	.....	
50,000	.0168	.....	
52,000	.0179	.....	
54,000	.0190	.....	
56,000	.0200	.....	
58,000	.0214	.....	
60,000	.0229	.....	Joint opened about ".01 or less.
5,000	.....	.0109	
62,000	.0240	.....	
64,000	.0249	.....	
66,000	.0264	.....	
68,000	.0279	.....	
70,000	.0298	.....	
72,000	.0314	.....	
74,000	.0338	.....	
76,000	.0361	.....	
78,000	.0404	.....	
80,000	.0445	.....	
82,000	.0505	.....	
84,000	.0541	.....	
86,000	.0634	.....	
88,000	.0724	.....	Joint opened about ".03.
90,000	.0890	.....	
105,300	.....	.....	Ultimate strength.

Fractured upper plate through line of four rivet holes. The fracture began at the holes.

Metal silky in appearance and well drawn down. After fracture the slip of the plates at the calked joint measured ".15. The joint was very greasy from oil used in punching.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	41,785
Tensile stain on net section of plate	65,400
Compressive strain on bearing surface of rivets	64,600
Shearing strain on rivets	30,430

No. 435.—¼" Steel Plate. Joint G . .

Same style of joint as No. 434.
Upper plate, 10" × ".254.
Under plate, 10" × ".254.
⅝" iron rivets, "Burden's best."
Punched holes: Punch, ".695 diameter; die, ".752 diameter.

	Square inches.
Gross sectional area of plate	2.54
Net sectional area of plate	1.63
Bearing surface of rivets	1.66
Shearing area of rivets (".70 diameter)	3.46

Specimen warped on the side.

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.....	.....	
10,000	.0003	.....	
15,000	.0010	.....	
20,000	.0014	.....	
5,000	.....	.0003	
25,000	.0024	.....	
30,000	.0037	.....	
35,000	.0053	.....	
5,000	.....	.0012	
40,000	.0077	.....	
44,000	.0092	.....	
48,000	.0110	.....	
50,000	.0122	.....	
52,000	.0131	.....	
54,000	.0142	.....	
56,000	.0152	.....	
58,000	.0162	.....	
60,000	.0172	.....	Joint hardly disturbed.
5,000	.....	.0077	
62,000	.0182	.....	
64,000	.0192	.....	
66,000	.0203	.....	
68,000	.0217	.....	
70,000	.0232	.....	
72,000	.0252	.....	
74,000	.0272	.....	
76,000	.0294	.....	
78,000	.0332	.....	
80,000	.0374	.....	Joint opened about ".03.
82,000	.0434	.....	
84,000	.0502	.....	
86,000	.0567	.....	
88,000	.0670	.....	
90,000	.0840	.....	
105,300	.....	.....	Ultimate strength.

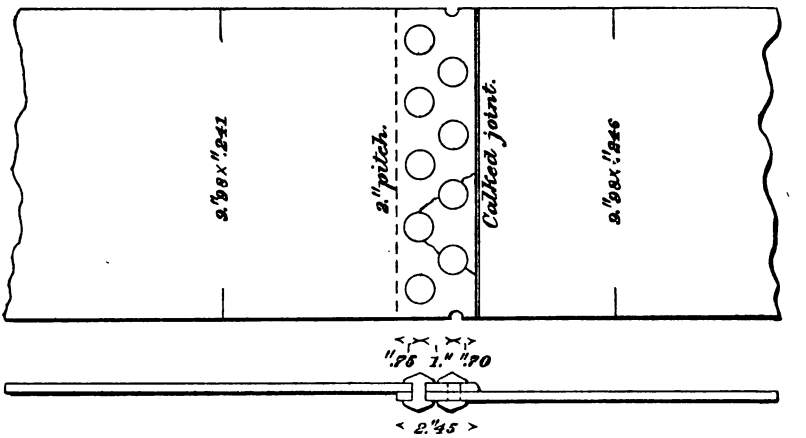
Failure occurred in the same manner as with G . Appearance of fracture, silky. Metal well drawn down. Joint greasy from oil used in punching.

The slip of the plates at the calked edge after fracture measured ".20, the joint remaining open about ".05 to ".06.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	41,460
Tensile strain on net section of plate	64,600
Compressive strain on bearing surface of rivets	63,430
Shearing strain on rivets	30,430

No. 87.—$\frac{1}{4}$″ Steel Plate. Joint I.



$\frac{7}{16}$″ steel rivets.
Drilled holes, ″.50 diameter.

	Square inches.
Gross sectional area of upper plate	2.41
Net sectional area of upper plate	1.80
Bearing surface of rivets	1.08
Shearing area of rivets	1.77

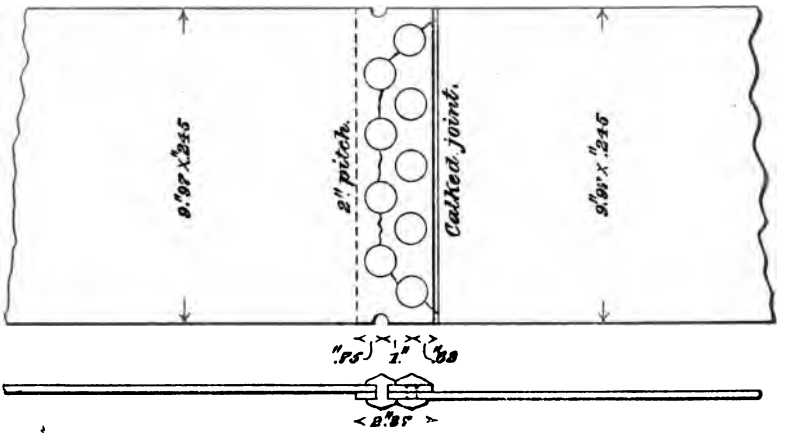
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0012		
30,000	.0028		
35,000	.0038		
40,000	.0050		
45,000	.0068		
50,000	.0090		
5,000		.0045	
55,000	.0120		
60,000	.0155		
65,000	.0195		
70,000	.0240		
75,000	.0305		Joint opened perceptibly.
80,000	.0390		Joint opened ″.01.
85,000	.0515		
90,000	.0715		Joint opened ″.02. Rapid stretching of plate.
102,500			Ultimate strength. Sheared six rivets and tore out plate at three rivets.

Average elongation of holes, about ″.15.
The minimum elongation, ″.07; maximum, ″.28.
The metal on one side of the plate proved its elastic limit before the full surface, owing to the plates not being riveted together in line.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	42,530
Tensile strain on net section of plate	56,944
Compressive strain on bearing surface of rivets	94,910
Shearing strain on rivets	57,910

No. 88.—$\frac{1}{4}$″ STEEL PLATE. JOINT I . .



$\frac{7}{16}$″ steel rivets.
Drilled holes, ″.50 diameter.

	Square inches.
Gross sectional area of plate	2.44
Net sectional area of plate	1.83
Bearing surface of rivets	1.10
Shearing area of rivets	1.77

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
20,000	.0038		
30,000	.0068		
40,000	.0110		
45,000	.0135		
50,000	.0162		
5,000		.0070	
55,000	.0198		
60,000	.0232		
65,000	.0280		
70,000	.0320		
75,000	.0370		
80,000	.0455		Joint opened perceptibly.
85,000	.0570		Joint opened .″01.
90,000	.0750		
95,000	.1450		Joint opened .″02.
108,200			Ultimate strength. Tore upper plate, as shown by lines on sketch.

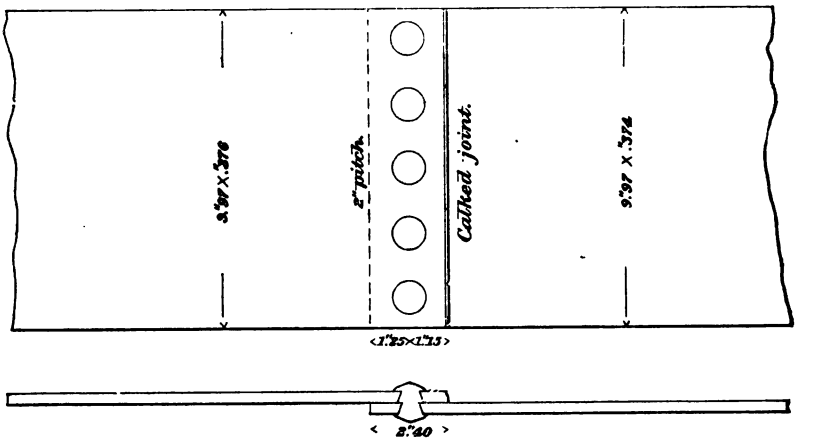
Fine silky fractures; metal well drawn down.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	44,344
Tensile strain on net section of plate	59,130
Compressive strain on bearing surface of rivets	98,360
Shearing strain on rivets	61,130

SINGLE-RIVETED LAP JOINTS, $\frac{3}{8}$″ STEEL PLATE.

No. 51.—$\frac{3}{8}$″ Steel Plate. Joint A.



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, ″.753 diameter; die, ″.774 diameter.

	Square inches.
Gross sectional area of lower plate	3.73
Net sectional area of lower plate	2.30
Bearing surface of rivets	1.427
Shearing area of rivets (″.76 diameter)	2.27

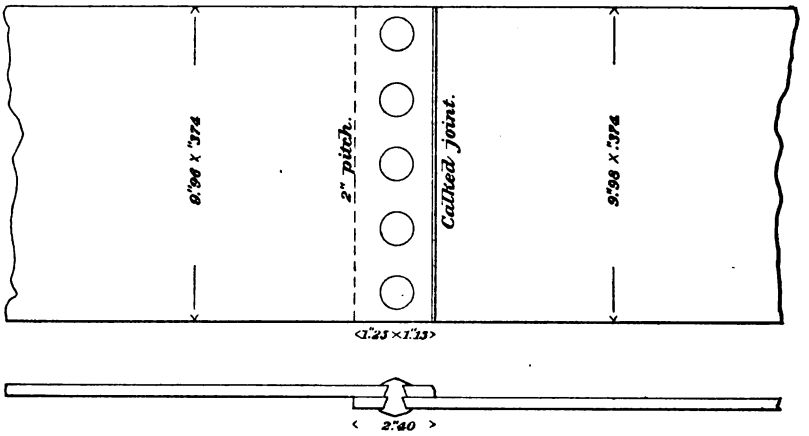
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0022		
30,000	.0060		
35,000	.0082		
5,000		.0038	
40,000	.0115		
45,000	.0140		
50,000	.0182		
55,000	.0248		
60,000	.0328		Joint opened less than ″.01.
65,000	.0495		Joint opened ″.02.
70,000	.0699		Joint opened ″.04.
75,000	.0980		
90,200			Ultimate strength. Sheared rivets.

Rivet holes elongated from ″.03 to ″.05.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	24,180
Tensile strain on net section of plate	39,220
Compressive strain on bearing surface of rivets	63,210
Shearing strain on rivets	39,740

No. 52.—⅜″ Steel Plate. Joint A . . .



$\frac{11}{16}$″ iron rivets, "Burden's best."
Punched holes.

	Square inches.
Gross sectional area of upper plate	3.73
Net sectional area of upper plate	2.30
Bearing surface of rivets	1.427
Shearing area of rivets (″.76 diameter)	2.27

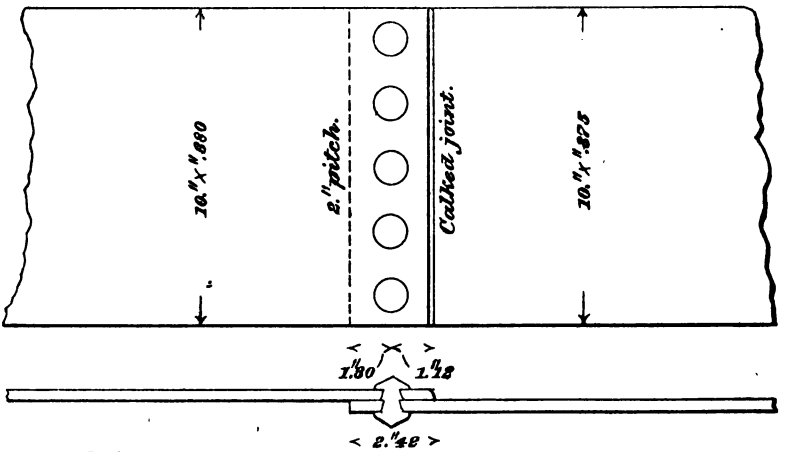
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.0		
10,000	.0008		
20,000	.0020		
30,000	.0060		
35,000	.0085		Joint started perceptibly.
5,000		.0039	
38,000	.0108		
40,000	.0118		
42,000	.0130		
44,000	.0145		
46,000	.0158		
48,000	.0172		
50,000	.0189		Joint opened about ″.01.
52,000	.0206		
54,000	.0230		
56,000	.0265		
58,000	.0318		
60,000	.0370		Joint opened ″.02.
62,000	.0420		
64,000	.0485		Joint opened ″.04.
66,000	.0560		
68,000	.0635		Joint opened ″.05.
70,000	.0728		
5,000		.0553	
86,700			Ultimate strength. Sheared rivets.

Rivet holes elongated from ″.03 to ″.05.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	23,240
Tensile strain on net section of plate	37,700
Compressive strain on bearing surface of rivets	60,760
Shearing strain on rivets	38,190

No. 53.—⅜″ Steel Plate. Joint A A.



$\frac{11}{16}$″ steel rivets.

Punched holes: Punch, ″.753 diameter; die, ″.774 diameter.

	Square inches.
Gross sectional area of lower plate	3.75
Net sectional area of lower plate	2.32
Bearing surface of rivets	1.43
Shearing area of rivets (″.76 diameter)	2.27

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0025		
30,000	.0060		
35,000	.0080		
5,000		.0030	
38,000	.0095		
40,000	.0110		
44,000	.0120		
46,000	.0130		
48,000	.0142		
50,000	.0159		
52,000	.0172		
54,000	.0190		Joint opened slightly.
56,000	.0203		
58,000	.0230		
60,000	.0260		
62,000	.0300		Joint opened ″.01.
64,000	.0340		
66,000	.0382		Joint open ″.02.
68,000	.0420		
70,000	.0461		Joint open ″.03.
72,000	.0510		
74,000	.0558		Joint open ″.04.
76,000	.0605		
78,000	.0661		Joint open ″.05.
80,000	.0725		
82,000	.0789		
84,000	.0845		
86,000	.0908		
88,000	.0980		
90,000	.1060		
128,100			Ultimate strength. Sheared rivets.

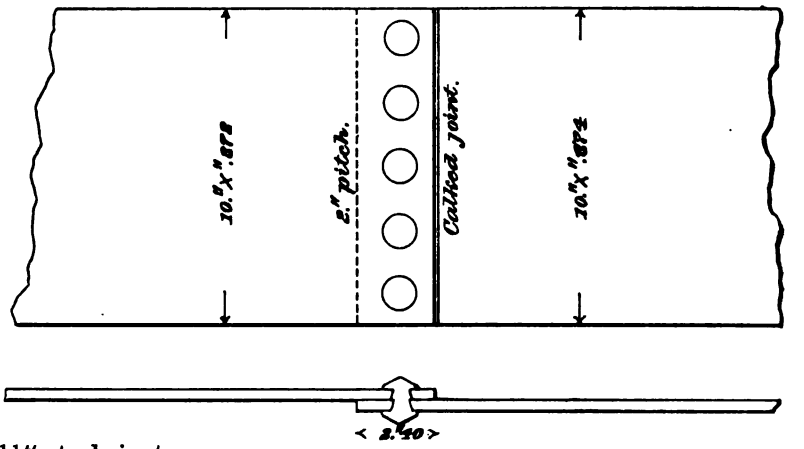
Average elongation of holes, ″.12.

Incipient fractures about rivet holes, indicating a close approach to the ultimate strength of the plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of lower plate	34,160
Tensile strain on net section of lower plate	55,215
Compressive strain on bearing surface of rivets	89,580
Shearing strain on rivets	56,430

No. 54.—$\frac{3}{8}$″ STEEL PLATE. JOINT A A . .



$\frac{11}{16}$″ steel rivets.

Punched holes: Punch, ″.753 diameter; die, ″.774 diameter.

	Square inches.
Gross sectional area of lower plate	3.75
Net sectional area of lower plate	2.32
Bearing surface of rivets	1.42
Shearing area of rivets (″.76 diameter)	2.27

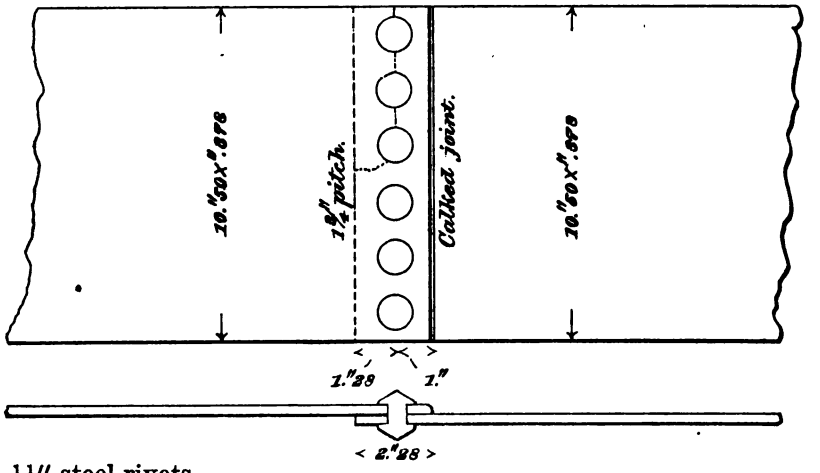
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0020		
30,000	.0048		
40,000	.0090		
50,000	.0149		
60,000	.0251		Joint open about ″.01.
70,000	.0450		
80,000	.0688		
90,000	.1038		
125,900			Ultimate strength. Sheared rivets.

Incipient fracture about rivet holes same as were developed in specimen A A .

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	33,840
Tensile strain on net section of upper plate	54,740
Compressive strain on bearing surface of rivets	88,660
Shearing strain on rivets	55,460

No. 55.—⅜″ Steel Plate. Joint E.



$\frac{11}{16}$″ steel rivets.
Drilled holes, ″.77 diameter.

	Square inches.
Gross sectional area of plate	3.97
Net sectional area of plate	2.22
Bearing surface of rivets	1.746
Shearing area of rivets (″.77 diameter)	2.79

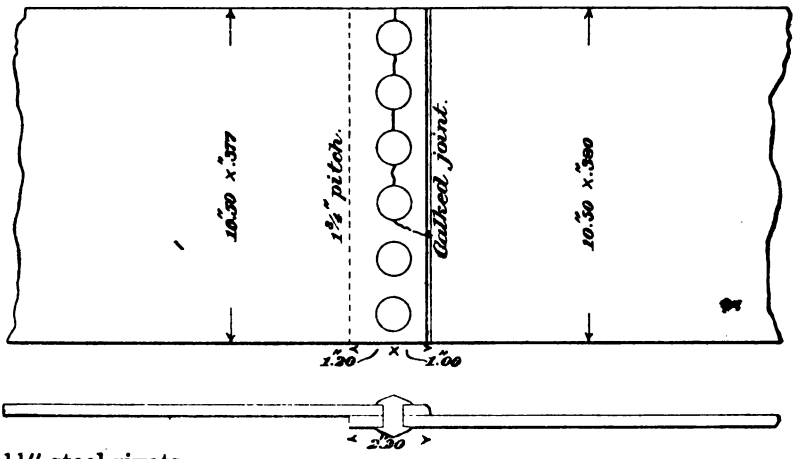
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	0016		
30,000	.0032		
35,000	.0048		
5,000		.0011	
40,000	.0070		
45,000	.0096		Joint opened perceptibly.
50,000	.0126		
55,000	.0156		
60,000	.0190		Joint open ″.01.
65,000	.0245		
68,000	.0282		Joint open ″.02.
70,000	.0330		
72,000	.0362		Joint open ″.03.
75,000	.0420		
78,000	.0480		Joint open ″.04.
80,000	.0522		
85,000	.0640		
90,000	.0770		
100,000	.1100		
124,400			Scale starts off entire plate.
141,300			Ultimate strength.

Sheared three rivets and tore apart the lower plate across three rivet holes, the metal showing a silky fracture, and drawing down well.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	35,590
Tensile strain on net section of plate	63,650
Compressive strain on bearing surface of rivets	80,930
Shearing strain on rivets	50,650

No. 56.—⅜″ STEEL PLATE. JOINT E . .



$\frac{11}{16}$″ steel rivets.
Drilled holes, ″.77 diameter.

	Square inches.
Gross sectional area of upper plate	3.96
Net sectional area of upper plate	2.22
Bearing surface of rivets	1.74
Shearing area of rivets (″.77 diameter)	2.79

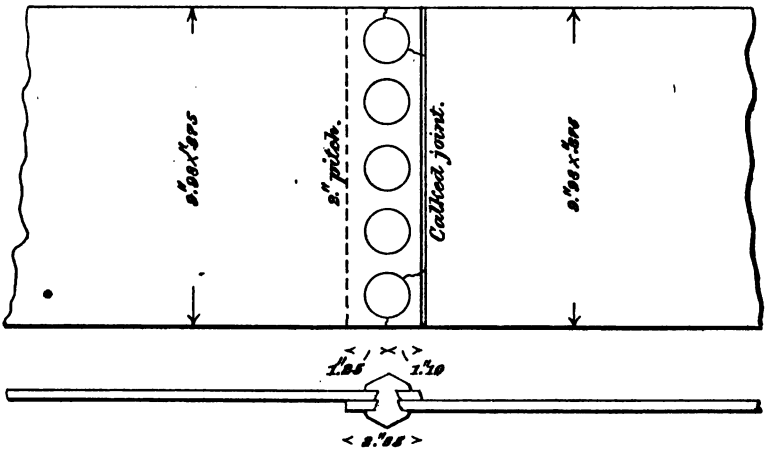
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	Plates not straight.
10,000	0.	.....	
20,100	.0010	.....	
30,000	.0018	.....	
35,000	.0021	.....	
5,000	.....	.0005	
40,000	.0039	.....	
45,000	.0056	.....	
50,000	.0085	.....	Joint opened perceptibly at 53,000 pounds tension.
55,000	.0125	.....	
60,000	.0168	.....	
65,000	.0225	.....	Joint open ″.01.
68,000	.0278	.....	
70,000	.0310	.....	Joint open ″.02.
72,000	.0348	.....	
75,000	.0410	.....	Joint open ″.03.
78,000	.0480	.....	Joint open ″.04.
80,000	.0530	.....	Joint open ″.05.
85,000	.0680	.....	
90,000	.0860	.....	
95,000	.1110	.....	
100,000	.1350	.....	
122,000	.....	.....	Scale starts off plates.
142,000	.....	.....	Ultimate strength.

Sheared two rivets and tore plate across four rivet holes in upper plate.
Silky fractures, the metal well drawn down.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	35,860
Tensile strain on net section of upper plate	63,976
Compressive strain on bearing surface of rivets	81,600
Shearing strain on rivets	50,900

No. 238.—$\frac{3}{8}$″ STEEL PLATE. JOINT C C.



$\frac{3}{4}$″ steel rivets.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $\frac{7}{8}$″ diameter.

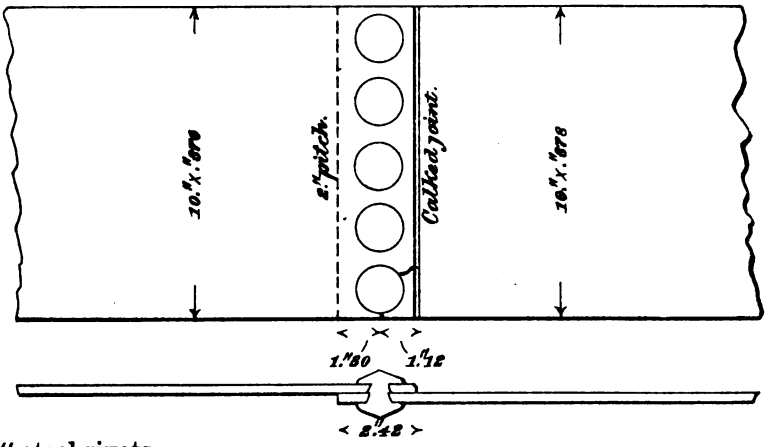
	Square inches.
Gross sectional area of upper plate	3.74
Net sectional area of upper plate	2.16
Bearing surface of rivets	1.58
Shearing area of rivets (″.82 diameter)	2.64

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
20,000	.0030		
30,000	.0055		
35,000	.0070		
5,000		.0012	
40,000	.0090		
45,000	.0112		
50,000	.0135		
55,000	.0165		
60,000	.0200		
65,000	.0242		Joint opened perceptibly.
5,000		.0130	
70,000	.0308		Joint open ″.01.
75,000	.0380		
80,000	.0540		Joint open ″.02.
85,000	.0700		Joint open ″.03.
90,000	.0830		
95,000	.0990		Joint open ″.04.
100,000	.1150		Joint open ″.05.
105,000	.1360		
110,000	.1630		
141,400			Ultimate strength. Sheared three rivets. Tore upper plate at end rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	37,810
Tensile strain on net section of plate	65,460
Compressive strain on bearing section of rivets	89,490
Shearing strain on rivets	53,560

No. 239.—$\frac{3}{8}$″ Steel Plate. Joint C C . .



$\frac{3}{4}$″ steel rivets.

Punched holes: Punch, $\frac{13}{16}$″ diameter; die, $\frac{7}{8}$″ diameter.

	Square inches
Gross sectional area of upper plate	3.76
Net sectional area of upper plate	2.17
Bearing surface of rivets	1.59
Shearing area of rivets (″.82 diameter)	2.64

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	.0019		
30,000	.0045		
35,000	.0060		
5,000		.0018	
40,000	.0079		
45,000	.0095		
50,000	.0112		
5,000		.0032	
55,000	.0140		
60,000	.0170		
65,000	.0212		Joint opened perceptibly.
5,000		.0106	
70,000	.0295		Joint open ″.01.
75,000	.0380		
80,000	.0520		Joint open ″.02.
85,000	.0660		
90,000	.0790		Joint open ″.04.
100,000	.1125		Micrometer removed.
110,000	.1500		
120,000	.2800		
130,000	.4700		
140,000	.6800		
141,500	.7800		Ultimate strength. Sheared four rivets. Tore out plate at end rivet, upper plate.

At time of maximum load the joint had slipped at the calked end ″.40.

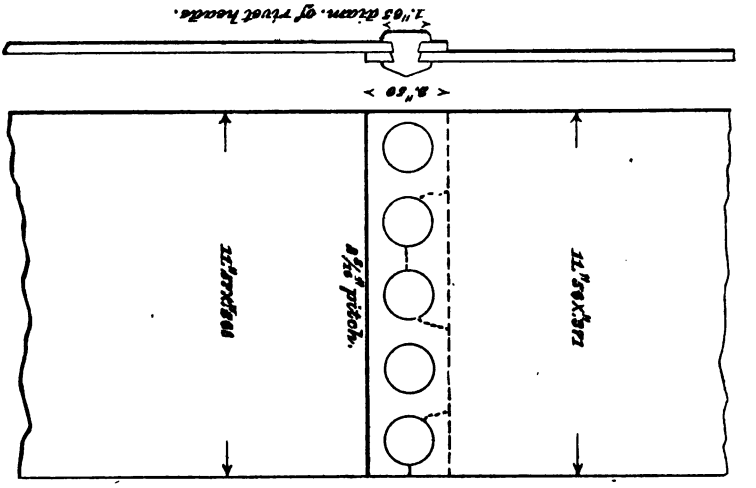
Elongation of holes in upper plate, punch side, ″.15; die side, ″29. Elongation of holes in lower plate, punch side, ″.13; die side, ″.07.

Fractures were started about two holes in the upper plate where the rivets had sheared, showing the metal was near the point of tearing out.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	37,630
Tensile strain on net section of plate	65,210
Compressive strain on bearing surface of rivets	88,990
Shearing strain on rivets	53,600

No. 718.—$\frac{3}{8}$″ STEEL PLATE. SET K.



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	4.25
Net sectional area of under plate	2.21
Bearing surface of rivets	2.04
Shearing area of rivets	4.43

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0028		
30,000	.0050		
35,000	.0068		
5,000		.0020	
40,000	.0088		
45,000	.0118		
50,000	.0148		
55,000	.0180		
60,000	.0215		
65,000	.0252		
70,000	.0298		
75,000	.0340		
80,000	.0388		
90,000	.07		
100,000	.11		
110,000	.14		
120,000	.19		
130,000	.24		
140,000	.30		
150,000	.49		
162,200			Ultimate strength.

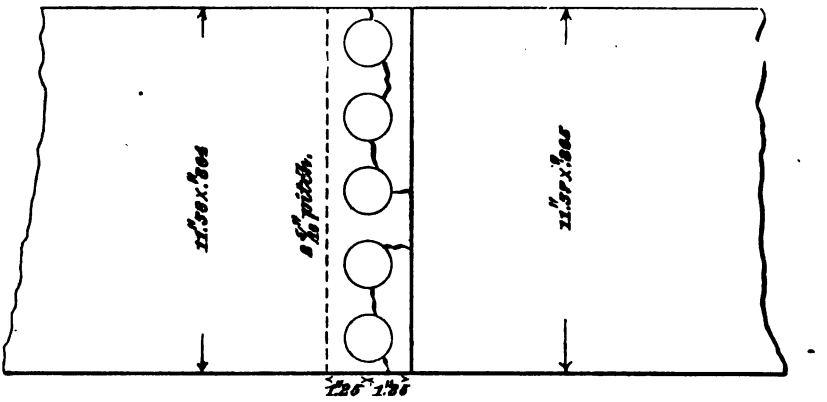
Sheared two rivets and tore out plate at three rivets under plate.
Elongation of two rivet holes, ".26 each.
Fracture of plate silky.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	38,075
Tensile strain on net section of under plate	73,394
Compressive strain on bearing surface of rivets	79,510
Shearing strain on rivets	36,614

No. 719.—$\frac{3}{8}$″ STEEL PLATE. SET K . .

Duplicate of K .



1″ iron rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	4.22
Net sectional area of upper plate	2.19
Bearing surface of rivets	2.02
Shearing area of rivets	4.43

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0010	.....	
20,000	.0030	.....	
30,000	.0051	.....	
35,000	.0065	.....	
5,000	.....	.0008	
40,000	.0080	.....	
45,000	.0100	.....	
55,000	.0150	.....	
60,000	.0161	.....	
65,000	.0200	.....	
70,000	.0240	.....	
75,000	.0290	.....	
80,000	.0340	.....	
85,000	.0388	.....	
90,000	.048	.....	
95,000	.056	.....	
100,000	.070	.....	
110,000	.11	.....	
120,000	.18	.....	
130,000	.18	.....	
140,000	.24	.....	
150,000	.47	.....	
160,000	.67	.....	
162,000	.....	.....	Ultimate strength.

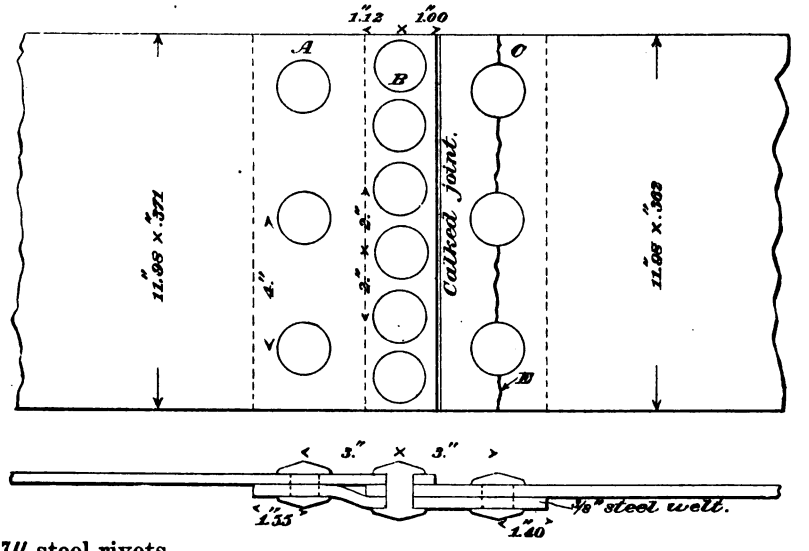
Tore out upper plate.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	38,390
Tensile strain on net section of upper plate	73,970
Compressive strain on bearing surface of rivets	80,200
Shearing strain on rivets	36,590

SINGLE-RIVETED LAP JOINTS, WITH REINFORCE WELT, $\frac{3}{8}$″ STEEL PLATE.

No. 246.—$\frac{3}{8}$″ STEEL PLATE. JOINT J.



$\frac{7}{8}$″ steel rivets.
Drilled holes, ″.94 diameter.

	Square inches.
Gross sectional area of under plate	4.34
Net sectional area of under plate through line of holes *B*	2.30
Net sectional area of under plate through line of holes *C*	3,32
Bearing surface of rivets (9) on under plate	3.06
Shearing area of 9 rivets (″.94 diameter), single shear	6.25

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0030		
35,000	.0038		
5,000		.0010	
40,000	.0045		
50,000	.0055		
60,000	.0092		
5,000		.0038	
65,000	.0112		
70,000	.0130		
75,000	.0148		
80,000	.0160		
85,000	.0180		
90,000	.0200		
95,000	.0218		Joint opened perceptibly.
100,000	.0240		
5,000		.0131	
105,000	.0270		
110,000	.0295		

Loads applied.	Elongation in 10 inches.	Permanent set	Remarks.
Pounds.	*Inch.*	*Inch.*	
115,000	.0325	....	Joint open ".01.
120,000	.0365	.....	
125,000	.0418	....	
130,000	.0480	.....	
135,000	.0580	.....	
140,000	.0820	.....	Micrometer removed.
145,000	.13	.....	
150,000	.16	.....	
155,000	.21	.....	
206,000	.....	.....	Ultimate strength. Fractured under plate at outside row of rivets.

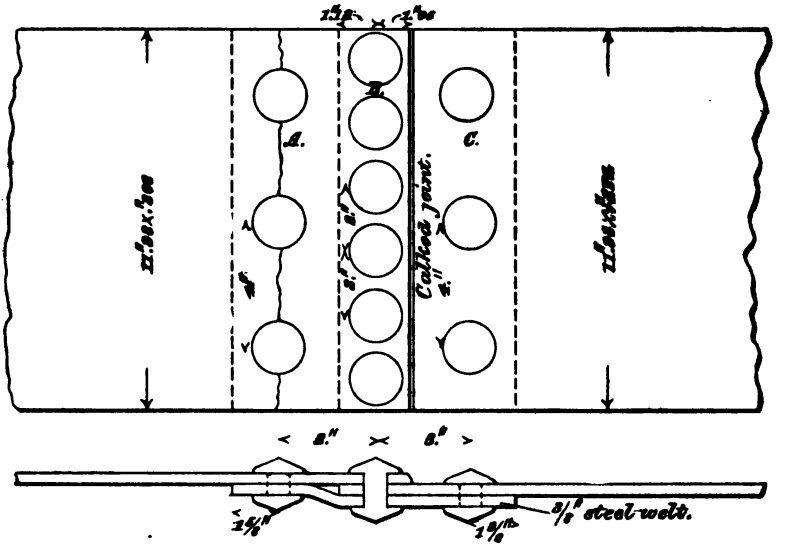
Fracture, silky seam in steel through one end section at *E*. After fracture, holes in welt elongated about ".02 each; upper plate, outside row of 3 holes, elongated ".20; upper plate, inside row of 6 holes, elongated ".06.

Before fracture the plates drew down from 11".98 to about 11".68 in width; the line of the joint bent concave and wavy.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of lower plate	47,465
Tensile strain on net section of under plate through line of holes *B*	89,565
Tensile strain on net section of under plate through line of holes *C*	62,050
Shearing strain on 9 rivets, single shear	32,960
Compressive strain on bearing surface of rivets (9) in under plate	67,320

No. 247.—$\frac{3}{8}$" STEEL PLATE. JOINT J . .



$\frac{7}{8}$" steel rivets.
Drilled holes, ".94 diameter.
$\frac{3}{8}$" steel welt.

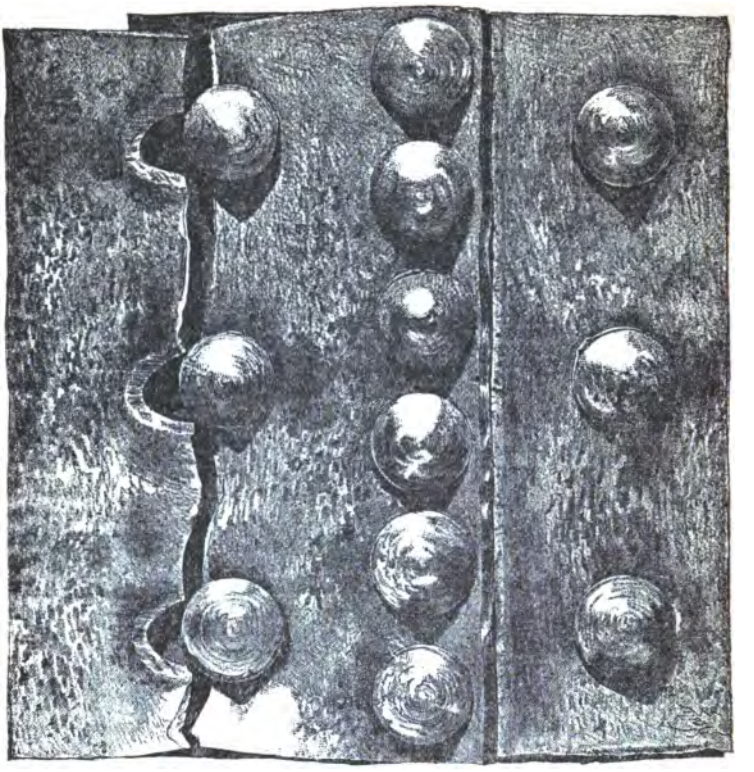
	Square inches.
Gross sectional area of upper plate	4.41
Net sectional area of upper plate through line of holes *A*	3.37
Net sectional area of upper plate through line of holes *B*	2.33
Bearing surface of 9 rivets, upper plate	3.11
Shearing area of 9 rivets (".94 diameter), single shear	6.25

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0005	.....	
20,000	.0012	.....	
30,000	.0022	.....	
35,000	.0029	.....	
5,000	.....	.0010	
40,000	.0038	.....	
50,000	.0058	.....	
60,000	.0080	.....	
5,000	.....	.0038	
65,000	.0098	.....	
70,000	.0110	.....	
75,000	.0128	.....	
80,000	.0142	.....	
85,000	.0158	.....	
90,000	.0170	.....	Joint opened perceptibly.
95,000	.0188	.....	
100,000	.0200	.....	
5,000	.....	.0108	
105,000	.0222	.....	
110,000	.0240	.....	
115,000	.0262	.....	
120,000	.0295	.....	
125,000	.0330	.....	
130,000	.0382	.....	
135,000	.0460	.....	
140,000	.0640	.....	Micrometer removed.
145,000	.12	.....	
150,000	.15	.....	
155,000	.18	.....	
160,000	.22	.....	
165,000	.26	.....	
170,000	.30	.....	
175,000	.34	.....	
180,000	.37	.....	
185,000	.43	.....	
190,000	.48	.....	
195,000	.52	.....	
200,000	.58	.....	
205,000	.68	.....	
210,000	.79	.....	
211,900	.....	.....	Ultimate strength. Fractured upper plate through outside row of rivets.

Fracture began at end rivet hole. This outside section has seam through the steel, same in appearce as developed in the test of J .
Fractures otherwise silky.

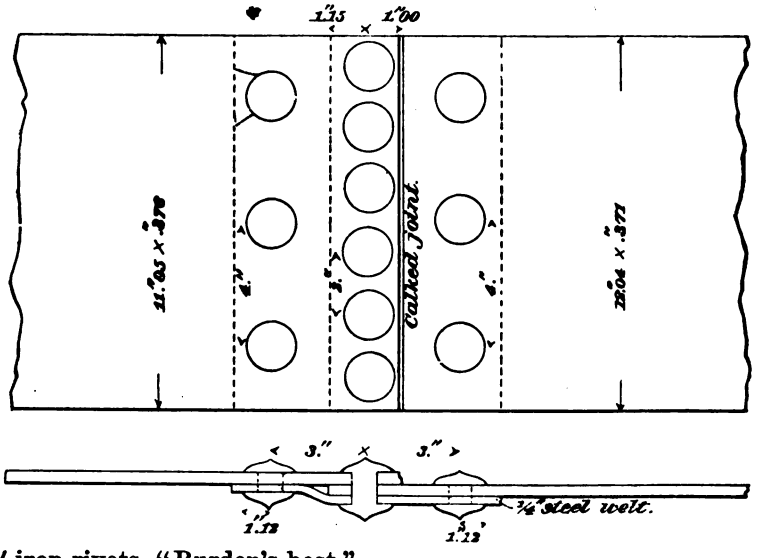
Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	48,050
Tensile strain on net section of upper plate across lines of holes *A*	62,880
Tensile strain on net section of upper plate across lines of holes *B*	90,940
Compressive strain on bearing surface of 9 rivets, upper plate	68,135
Shearing strain on 9 rivets, single shear0	33,90



Photograph of joint No. 247. Appearance after the fracture.

No. 298.—⅜″ Steel Plates. Joint J J.



⅞″ iron rivets, "Burden's best."
Drilled holes, ″.93 diameter.

	Square inches.
Gross sectional area of under plate	4.47
Net sectional area of under plate across row of three rivet holes	3.43
Bearing surface of rivets	3.11
Shearing area of rivets (9 rivets, single shear)	6.11

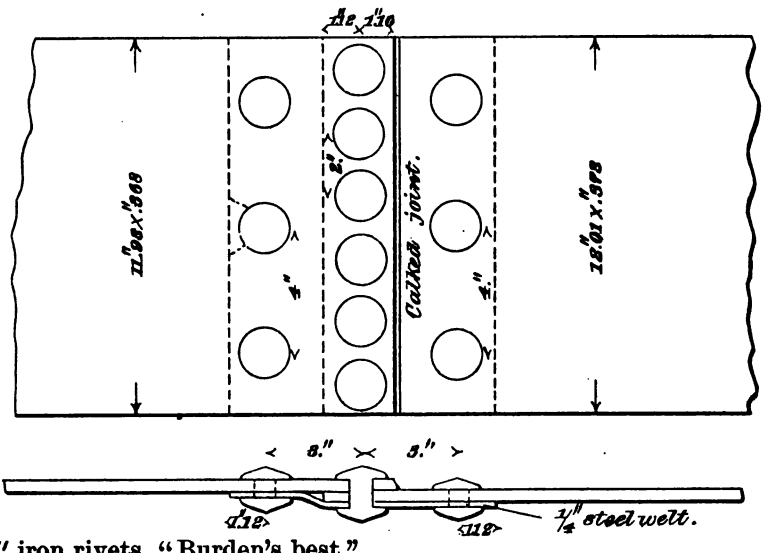
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.0		
10,000	.0005		
20,000	.0015		
30,000	.0028		
40,000	.0046		
50,000	.0075		
5,000		.0018	
60,000	.0108		
70,000	.0150		
80,000	.0198		
90,000	.0248		
100,000	.0320		
110,000	.0400		
120,000	.0560		
130,000	.09		
140,000	.11		
150,000	.17		
209,300			Ultimate strength. Sheared eight rivets and tore out one hole in ¼" welt.

	Inch.
Average elongation of rivet holes in upper plate, outside row (3 holes)	.32 each.
Upper plate, inside row (6 holes)	.24 each.
Lower plate, inside row (6 holes)	.26 each.
¼" welt, inside row (6 holes)	about .02 each.
¼" welt, outside row (3 holes)	.31 each.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	46,820
Tensile strain on net section of under plate across line of three rivet holes	61,020
Compressive strain on bearing surface of rivets	67,300
Shearing strain on rivets (single shear)	34,250

No. 299.—⅜" Steel Plate. Joint J J . .



⅞" iron rivets, "Burden's best."
Drilled holes, ".93 diameter.

	Square inches.
Gross sectional area of under plate	4.48
Net sectional area of under plate across row of three rivet holes	3.44
Bearing surface of rivets	3.12
Shearing area of rivets (single shear)	6.11

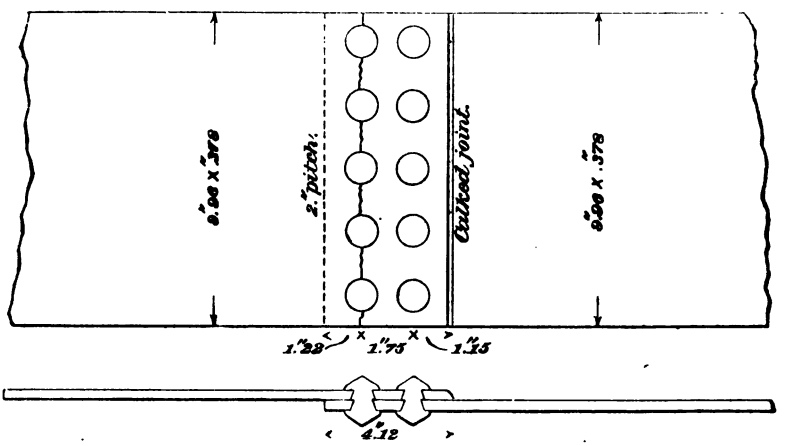
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.0		
10,000	.0005		
20,000	.0010		
30,000	.0022		
40,000	.0042		
50,000	.0072		
5,000		.0022	
60,000	.0110		
70,000	.0148		
80,000	.0190		
90,000	.0230		
100,000	.029		
110,000	.06		
120,000	.07		
130,000	.08		
140,000	.11		
150,000	.19		
212,300			Ultimate strength. Sheared eight rivets; tore out ¼" welt at middle rivet, outside row.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	47,390
Tensile strain on net section of under plate across row of three rivet holes	61,710
Compressive strain on bearing surface of rivets	68,040
Shearing strain on rivets (single shear)	34,750

DOUBLE-RIVETED LAP-JOINTS, ⅜" STEEL PLATE.

No. 57.—⅜" STEEL PLATE. JOINT F.



11/16" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of plate	3.76
Net sectional area of plate	2.32
Bearing surface of rivets	2.89
Shearing area of rivets (".76 diameter)	4.54

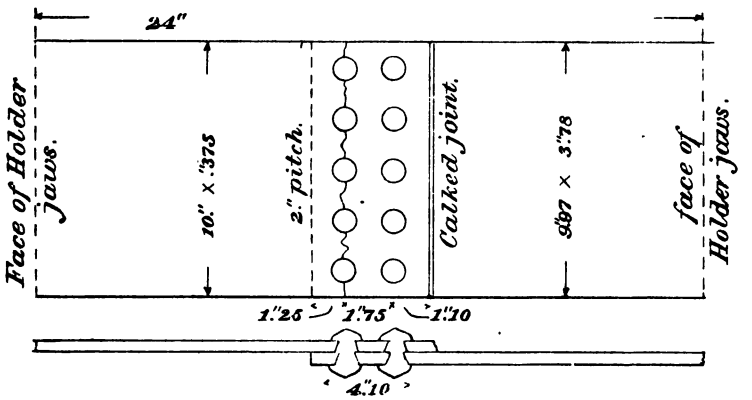
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0010	.....	
20,000	.0030	.....	
30,000	.0050	.....	
35,000	.0068	.....	
5,000	.....	.0020	
40,000	.0080	.....	
45,000	.0100	.....	
50,000	.0121	.....	
55,000	.0142	.....	
60,000	.0170	.....	Joint opened perceptibly.
65,000	.0200	.....	
70,000	.0240	.....	
75,000	.0285	.....	Joint open ".01.
80,000	.0330	.....	
85,000	.0389	.....	
90,000	.0440	.....	Joint open ".02.
95,000	.0508	.....	
100,000	.0580	.....	Joint open ".03.
105,000	.0678	.....	
110,000	.0830	.....	Joint open ".06. Scale started off plates.
146,700	.....	.....	Ultimate strength.

Fractured upper plate along line of rivet holes; silky fractures; metal drew down well, and fractured in each section at the same time.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	39,020
Tensile strain on net section of plate	62,800
Compressive strain on bearing surface of rivets	50,760
Shearing strain on rivets	32,310

No. 59.—$\frac{3}{8}$" STEEL PLATE. JOINT F..



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

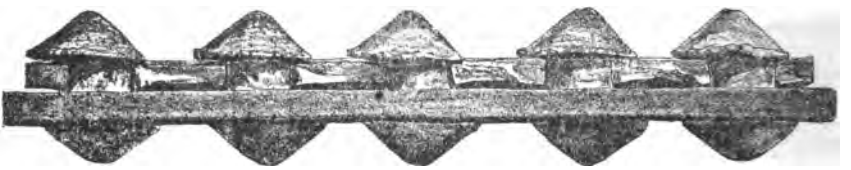
	Square inches.
Gross sectional area of upper plate	3.73
Net sectional area of upper plate	2.31
Bearing surface of rivets	2.85
Shearing area of rivets (".76 diameter)	4.54

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0008	.....	
20,000	.0015	.....	
30,000	.0025	.....	
40,000	.0042	.....	
50,000	.0069	.....	
5,000	.....	.0009	
58,000	.0081	.....	
60,000	.0100	.....	
65,000	.0118	.....	
70,000	.0140	.....	
5,000	.....	.0040	
75,000	.0168	.....	Joint opened perceptibly.
80,000	.0205	.....	
85,000	.0250	.....	
90,000	.0310	.....	Joint open ".01.
95,000	.0370	.....	
100,000	.0430	.....	
105,000	.0505	.....	Joint open ".03.
110,000	.0590	.....	
5,000	.....	.0430	
149,500	.....	.....	Ultimate strength.

Fractured upper plate. Silky fractures.

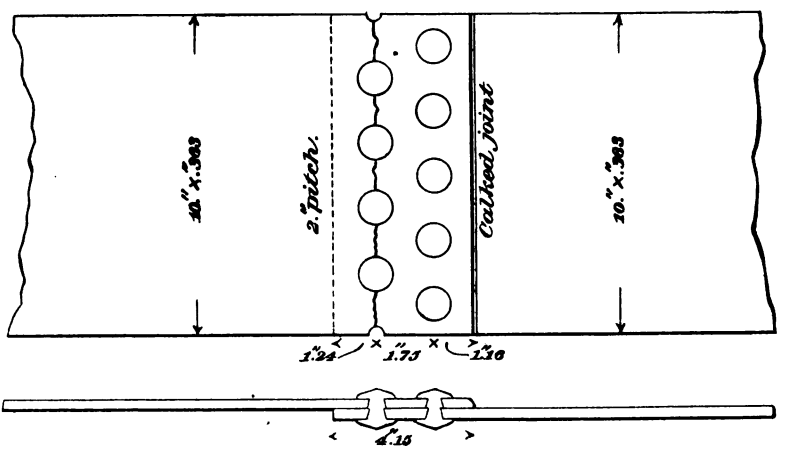
Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	40,080
Tensile strain on net section of upper plate	64,720
Compressive strain on bearing surface of rivets	52,450
Shearing strain on rivets	32,930



Photograph showing eccentricity of rivet heads, Joint No. 59.

No. 60.—$\frac{3}{8}$" STEEL PLATE. JOINT G.



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of plate	3.63
Net sectional area of plate	2.24
Bearing surface of rivets	2.49
Shearing area of rivets (".76 diameter)	4.08

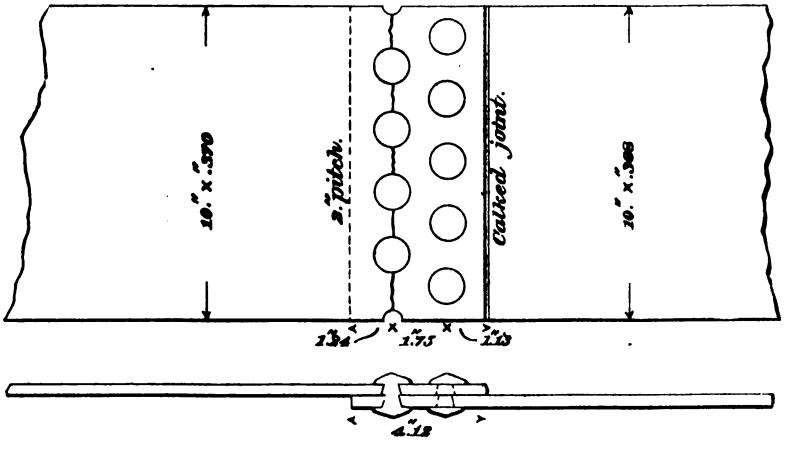
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0020		
30,000	.0040		
40,000	.0068		
50,000	.0108		
5,000		.0029	
60,000	.0160		
65,000	.0190		
70,000	.0231		
5,000		.0106	
75,000	.0280		Joint open perceptibly.
80,000	.0339		Joint open ".01.
85,000	.0398		
90,000	.0460		Joint open ".02.
5,000		.0300	
95,000	.0540		Joint open ".03.
100,000	.0668		
105,000	.0778		Joint open ".05.
110,000	.0920		
115,000	.1098		
141,600			Ultimate strength.

Fractured upper plate along line of rivet holes; silky fractures; metal hard about holes, with small granular spots near punched holes.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	39,010
Tensile strain on net section of plate	63,210
Compressive strain on bearing surface of rivets	56,860
Shearing strain on rivets	34,710

No. 61.—$\frac{3}{8}$" Steel Plate. Joint G . .



$\frac{11}{16}$" iron rivets, "Burden's best."
Punched holes: Punch, ".753 diameter; die, ".774 diameter.

	Square inches.
Gross sectional area of upper plate	3.70
Net sectional area of upper plate	2.29
Bearing surface of rivets	2.54
Shearing area of rivets (".76 diameter)	4.06

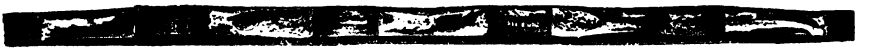
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	.0		
10,000	.0005		
20,000	.0013		
30,000	.0028		
40,000	.0046		
50,000	.0079		
5,000		.0021	
60,000	.0122		
65,000	.0150		
70,000	.0180		
5,000		.0085	
75,000	.0238		Joint opened perceptibly.
80,000	.0288		Joint open ".01.
85,000	.0340		Joint open ".02.
90,000	.0405		Joint open ".03.
5,000		.0271	Joint open ".01+.
95,000	.0480		Joint open ".04.
100,000	.0605		Joint open ".05.
105,000	.0720		
*110,000			Approximately the elastic limit of the plate = 29,730 pounds per square inch.
125,800			Ultimate strength. Fractured plate.

Sharp but not loud report heard at 100,000 pounds and again heard just before fracture of the plate.

Fractured plate across row of four rivet holes; the metal first separated at the middle sections, which displayed in part fine granular fractures and in part silky appearance.

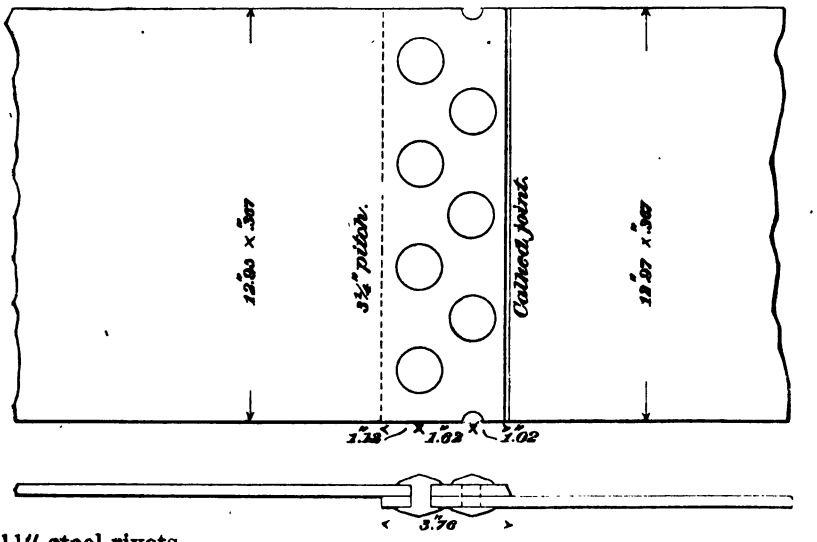
Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	34,000
Tensile strain on net section of upper plate	54,930
Compressive strain on bearing surface of rivets	49,530
Shearing strain on rivet	30,830



Photograph of fractured plate, showing granular metal, next two rivet holes, radiating from rivet holes.

No. 83.—⅜″ Steel Plate. Joint I.



11/16″ steel rivets.
Drilled holes, ″.75 diameter.

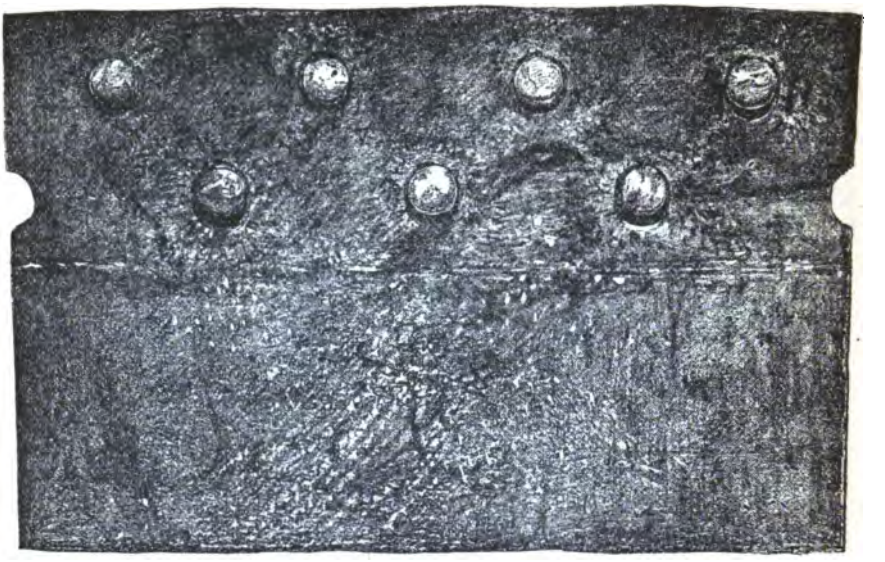
	Square inches.
Gross sectional area of upper plate	4.75
Net sectional area of upper plate	3.65
Bearing surface of rivets	1.93
Shearing area of rivets (″.75 diameter)	3.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	0.	.....	
20,000	.0011	.....	
30,000	.0029	.....	
40,000	.0055	.....	
50,000	.0090	.....	
60,000	.0145	.....	
65,000	.0170	.....	
5,000	.....	.0079	
70,000	.0200	.....	
75,000	.0230	.....	
80,000	.0260	.....	Joint started perceptibly.
85,000	.0309	.....	
90,000	.0340	.....	Joint open ″.01.
95,000	.0408	.....	
100,000	.0528	.....	Joint open ″.03.
105,000	.0620	.....	Joint open ″.05.
110,000	.0708	.....	
115,000	.0815	.....	
120,000	.0945	.....	
125,000	.1085	.....	
130,000	.1220	.....	
163,000	.....	.....	Ultimate strength. Sheared rivets.

Average elongation of holes, ″.13 each.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	34,316
Tensile strain on net section of plate	44,660
Compressive strain on bearing surface of rivets	84,460
Shearing strain on rivets	52,750



Photograph of under plate, Joint No. 83. Appearance after rivets were sheared, showing the development of "Cooper lines."

No. 84.—$\frac{3}{8}$″ STEEL PLATE. JOINT I . .

Same style of joint as No. 83.
Upper plate, 12″.96 × ″.368.
Under plate, 12″.96 × ″.370.
$\frac{11}{16}$″ steel rivets.
Drilled holes, ″.75.

	Square inches.
Gross sectional area of upper plate	4.77
Net sectional area of upper plate	3.67
Bearing surface of rivets	1.93
Shearing area of rivets (″.75 diameter)	3.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	0.		
20,000	.0008		
30,000	.0018		
40,000	.0039		
50,000	.0070		
55,000	.0090		
60,000	.0108		
65,000	.0121		
5,000		.0061	
70,000	.0140		
75,000	.0160		
80,000	.0192		
85,000	.0225		
90,000	.0270		Joint opened perceptibly.
95,000	.0330		Joint open ″.01.
100,000	.0425		
105,000	.0515		Joint open ″.02.
110,000	.0628		Joint open ″.03.
115,000	.0700		Joint open ″.04.
120,000	.0830		Joint open ″.05.
160,200			Ultimate strength. Sheared rivets.

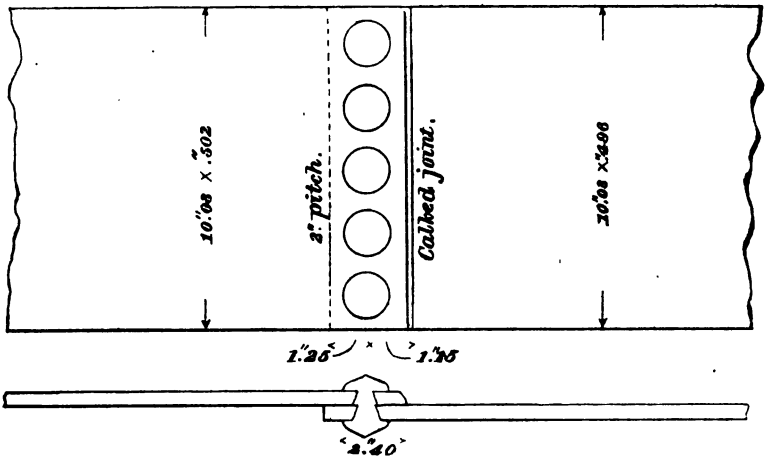
Average elongation of rivet holes, ″.13 each.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strength on gross section of plate	33,585
Tensile strength on net section of plate	43,650
Compressive strain on bearing surface of rivets	83,000
Shearing strain on rivets	83,000

SINGLE AND DOUBLE RIVETED LAP JOINTS, ¼" STEEL PLATE.

No. 242.—½" STEEL PLATE. JOINT A.



¾" iron rivets, "Burden's best."
Punched holes: Punch, $\frac{13}{16}$" diameter; die, $\frac{29}{32}$" diameter.

	Square inches.
Gross sectional area of under plate	4.97
Net sectional area of under plate	2.84
Bearing surface of rivets	2.13
Shearing area of rivets (".82 diameter)	2.64

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0009	.....	
20,000	.0020	.....	
30,000	.0042	.....	
35,000	.0068	.....	
5,000	.....	.0025	
10,000	.0030	.....	
20,000	.0045	.....	
30,000	.0060	.....	
35,000	.0068	.....	
5,000	.....	.0025	
40,000	.0095	.....	
45,000	.0125	.....	
50,000	.0160	.....	
5,000	.....	.0080	
10,000	.0088	.....	
20,000	.0102	.....	
30,000	.0120	.....	
40,000	.0141	.....	
50,000	.0168	.....	
55,000	.0190	.....	
60,000	.0225	.....	Joint opened perceptibly.
65,000	.0280	.....	
70,000	.0360	.....	
75,000	.0462	.....	Joint open ".01.
80,000	.0590	.....	
85,000	.0760	.....	Joint open ".02½.
90,000	.097	.....	
100,000	.....	.....	Micrometer removed.
108,500	.....	.....	Ultimate strength. Sheared rivets.

Failure took place immediately after the first warning that the rivets were yielding.

Elongation of rivet holes from ".04 to ".06.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	21,830
Tensile strain on net section of plate	38,204
Compressive strain on bearing surface of rivets	50,940
Shearing strain on rivets	41,100

No. 243.—½" Steel Plate. Joint A..

Same style of joint as No. 242.
Under plate, 10".04 × ".500.
Under plate, 10".04 × ".495.
¾" iron rivets, "Burden's best."
Punched holes: Punch, 13/16" diameter; 13/16" diameter of die.

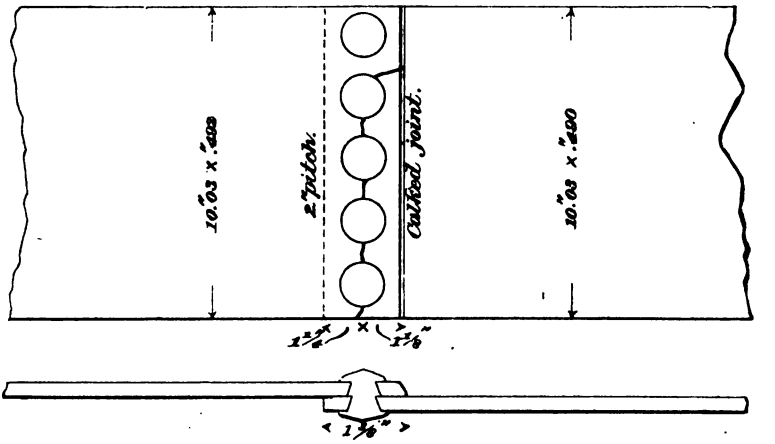
	Square inches.
Gross sectional area of under plate	4.97
Net sectional area of under plate	2.84
Bearing surface of rivets	2.13
Shearing area of rivets (".82 diameter)	2.64

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0020		
30,000	.0035		
35,000	.0050		
5,000		.0012	
40,000	.0080		
45,000	.0118		
50,000	.0150		
5,000		.0068	
55,000	.0180		
60,000	.0220		
65,000	.0300		Joint opened perceptibly.
70,000	.0395		
75,000	.0500		Joint open ".01.
80,000	.0630		
85,000	.0790		Micrometer removed.
90,000	.11		
95,000	.13		
100,000	.16		
102,000			Ultimate strength. Sheared rivets.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	29,523
Tensile strain on net section of plate	35,915
Compressive strain on bearing surface of rivets	47,890
Shearing strain on rivets	38,636

No. 294.—½″ Steel Plate. Joint A A.



$\frac{15}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, 1″ diameter; die, $1\frac{1}{16}$″ diameter.

	Square inches.
Gross sectional area of upper plate	4.93
Net sectional area of upper plate	2.40
Bearing surface of rivets	2.536
Shearing area of rivets (1″ diameter)	3.93

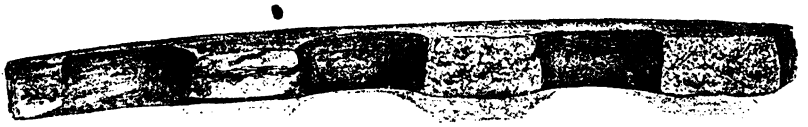
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	.0019		
30,000	.0035		
35,000	.0042		
5,000		.0010	
40,000	.0058		
45,000	.0071		
50,000	.0091		Joint started perceptibly.
55,000	.0115		Joint open ″.01.
60,000	.0142		
65,000	.0170		
70,000	.0210		
75,000	.0278		
80,000	.0368		
85,000	.0445		
90,000	.0550		Joint open ″.02.
100,000	.10		
110,000	.14		
120,000	.17		
144,500			Ultimate strength.

Tore plate across four rivet holes, shearing one end rivet.

The plate failed at the commencement of fracture by parting the middle sections, which showed a granular appearance. Metal not drawn down. Two sections between rivets have silky appearance, with seam through middle. Metal drawn down.

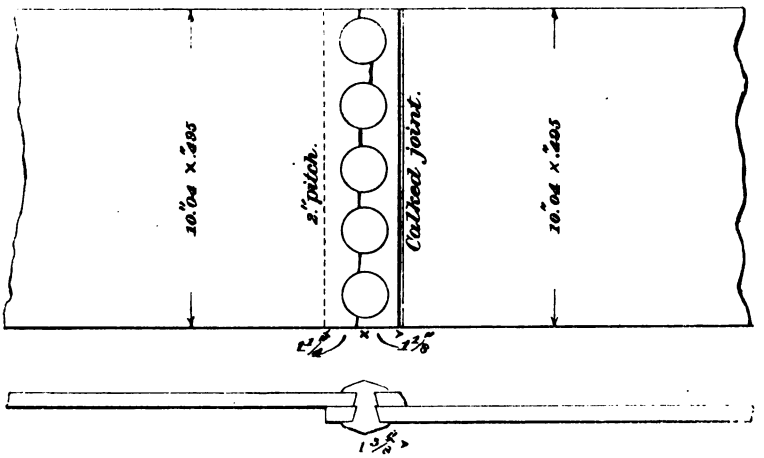
Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	29,310
Tensile strain on net section of upper plate	60,210
Compressive strain on bearing surface of rivets	56,980
Shearing strain on rivets	63,770



Fractured end of upper plate, Joint No. 294, showing granular and silky appearance in same metal.

No. 295.—½″ Steel Plate. Joint A. A . .



$\frac{15}{16}$″ iron rivets, "Burden's best."

Punched holes: Punch, 1″ diameter; die, $1\frac{1}{16}$″ diameter.

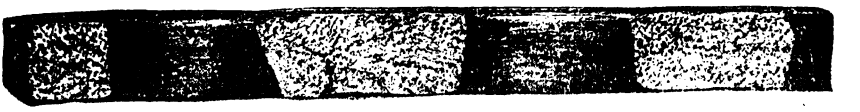
	Square inches.
Gross sectional area of plate	4.97
Net sectional area of plate	2.42
Bearing surface of rivets	2.55
Shearing area of rivets (1″ diameter)	3.93

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0038		
35,000	.0050		
5,000		.0010	
40,000	.0068		
45,000	.0088		
50,000	.0110		
55,000	.0130		
60,000	.0165		Joint opened perceptibly.
65,000	.0210		
70,000	.0248		
75,000	.0300		
80,000	.0360		Joint open ".01.
85,000	.0480		
90,000	.0625		
100,000	.10		Sharp snapping sound heard.
110,000	.14		Sharp snapping sound repeated at 104,500 pounds.
120,000			Ultimate strength.

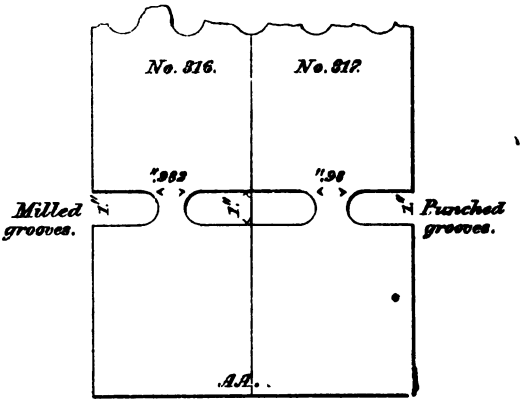
Broke suddenly across rivet holes; appearance of fracture granular; no contraction.

Maximum loads on joint.

	Pounds per sq. inch.
Tension strain on gross section of plate	24,145
Tension strain on net section of plate	49,590
Compression strain on bearing surface of rivets	47,060
Shearing strain on rivets	30,540



Photograph of fractured sections, upper plate, Joint No. 295. Granular fractures produced in the lap oint.



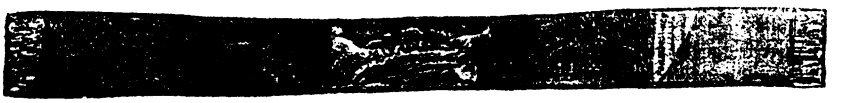
Specimens cut out of fractured plate A A . . No. 295. Tested by direct tension.

Sheet cut in two at middle.
One-half prepared with milled grooves.
One-half prepared with punched grooves.

No. 316.—MILLED SPECIMEN.

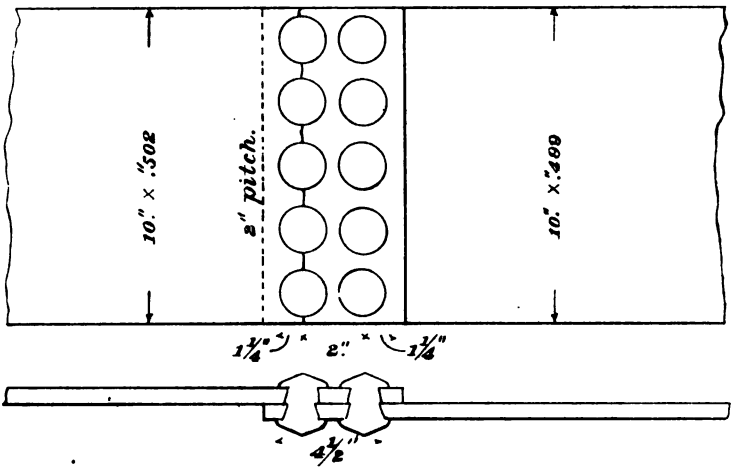
Sectional area, ″.982×″.495 = .486 square inch.
Ultimate strength, 32,850 pounds = 67,600 pounds per square inch.
Area at fracture, ″.88×″.33 = .290 square inch.
Contraction of area, 40.3 per cent.
Silky fracture; spongy line through center.

No. 317.—PUNCHED SPECIMEN.



Sectional area, ″.98×″.501 = .49 square inch.
Ultimate strength, 32,790 pounds = 66,920 pounds per square inch.
Area at fracture, ″.92×″.36 = .33 square inch.
Contraction of area, 32.7 per cent.
Appearance of fracture, silky, with slight granular appearance at center.

No. 619.—½″ Steel Plate. Plates C.



$\frac{15}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, 1″ diameter; die, $1\frac{3}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	5.02
Net sectional area of upper plate	2.39
Bearing surface of rivets	5.26
Shearing area of rivets	7.85

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0020		
30,000	.0040		
35,000	.0052		
5,000		.0019	
40,000	.0068		
45,000	.0080		
50,000	.0098		
5,000		.0045	
55,000	.0120		
60,000	.0140		
65,000	.0166		
70,000	.0190		
5,000		.0110	Micrometer removed.
75,000	.035		Elongations measured with dividers.
80,000	.035		
85,000	.04		
90,000	.05		
95,000	.05		
100,000	.06		
105,000	.06		
110,000	.07		
115,000	.07		
120,000	.07		
125,000	.08		
130,000	.085		
154,400			Ultimate strength.

Fractured upper plate across line of rivet holes.

Five of the fractured sections broke suddenly, with granular appearance and without contraction of area.

The sixth end section had silky appearance, the metal drawing down before breaking.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	30,757
Tensile strain on net section of upper plate	64,602
Compressive strain on bearing surface of rivets	29,354
Shearing strain on rivets	19,670

No. 620.—½″ Steel Plate. Plates C . .

(Duplicate of C .)

Same style of joint as No. 619.
Upper plate, 10″ × ″.501.
Under plate, 10″ × ″.502.
$\frac{15}{16}$″ iron rivets, "Burden's best."
Punched holes: Punch, 1″ diameter; die, $1\frac{3}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	5.01
Net sectional area of upper plate	2.39
Bearing surface of rivets	5.25
Shearing area of rivets	7.85

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0005	.....	
20,000	.0018	.....	
30,000	.0035	.....	
35,000	.0048	.....	
5,000	.....	.0012	
40,000	.0060	.....	
45,000	.0070	.....	
50,000	.0089	.....	
5,000	.....	.0030	
55,000	.0108	.....	
60,000	.0125	.....	
65,000	.0148	.....	
70,000	.0162	.....	
5,000	.....	.0090	
75,000	.0198	.....	
80,000	.0230	.....	
85,000	.0268	.....	
90,000	.0305	.....	
95,000	.0348	.....	
100,000	.0390	.....	
5,000	.....	.0268	Micrometer removed.
105,000	.07—	.....	
110,000	.07—	.....	
115,000	.07—	.....	
120,000	.07+	.....	
130,000	.08	.....	
140,000	.10	.....	
150,000	.14	.....	
154,200	.....	.....	Ultimate strength.

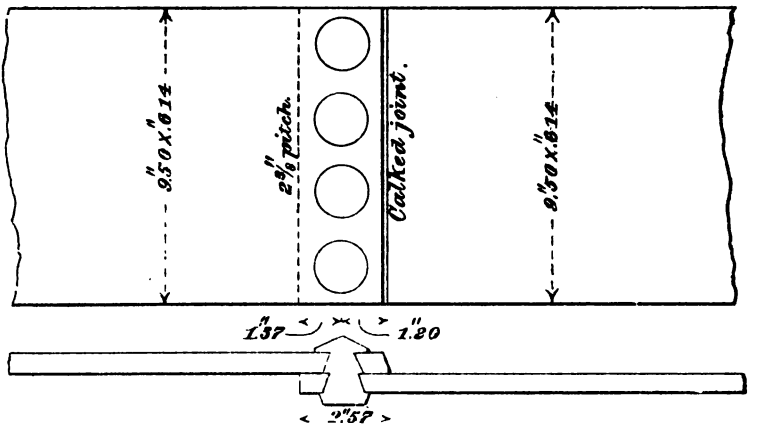
Fractured upper plate across line of rivet holes.
Broke suddenly, fractures granular. No contraction of area.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	30,778
Tensile strain on net section of upper plate	64,519
Compressive strain on bearing surface of rivets	29,371
Shearing strain on rivets	19,644

SINGLE AND DOUBLE RIVETED LAP JOINTS, $\frac{5}{8}$″ STEEL PLATE.

No. 734.—$\frac{5}{8}$″ STEEL PLATE. SET A.



1″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of plate	5.83
Net sectional area of plate	3.11
Bearing surface of rivets	2.72
Shearing area of rivets	3.55

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0018		
30,000	.0035		
40,000	.0068		
50,000	.0108		
60,000	.0160		
65,000	.0188		
70,000	.0225		
75,000	.0280		
80,000	.0348		
85,000	.0455		
90,000	.0600		
100,000	.09		
110,000	.14		
120,000	.17		
130,000	.22		Slight snapping sound at 132,000 pounds.
140,000			
154,400			Ultimate strength.

Sheared rivets.
Average elongation of rivet holes, ".15.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plate	26,480
Tensile strain on net section of plate	49,650
Compressive strain on bearing surface of rivets	56,760
Shearing strain on rivets	43,490

No. 735.—⅝″ Steel Plate. Set A . .

Duplicate of A . No. 734.

Upper plate, 9″.50 × ″.617.
Under plate, 9″.50 × ″.613.
1″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of under plate	5.82
Net sectional area of under plate	3.10
Bearing surface of rivets	2.72
Shearing area of rivets	3.55

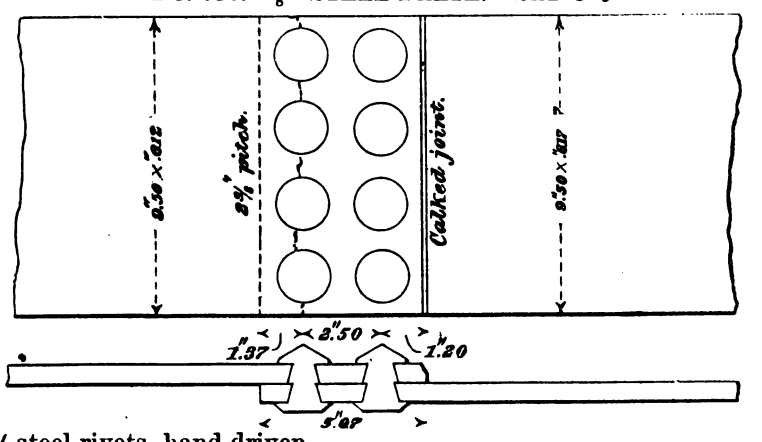
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0018		
30,000	.0031		
35,000	.0040		
40,000	.0050		
45,000	.0066		
50,000	.0082		
55,000	.0105		
60,000	.0128		
65,000	.0152		
70,000	.0185		
75,000	.0220		
80,000	.0280		
85,000	.0370		
90,000	.0570		
100,000	.09		
110,600	.13		
140,000	.28		
163,600			Ultimate strength.

Sheared rivets.
Average elongation of rivet holes, ″.11.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of under plate	28,110
Tensile strain on net section of under plate	52,770
Compressive strain on bearing surface of rivets	60,150
Shearing strain on rivets	46,080

No. 736.—⅝″ Steel Plate. Set C .



1″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	5.81
Net sectional area of upper plate	3.10
Bearing surface of rivets	5.43
Shearing area of rivets	7.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0006		
20,000	.0018		
30,000	.0030		
40,000	.0058		
50,000	.0080		
60,000	.0120		
65,000	.0148		
70,000	.0175		
75,000	.0208		
80,000	.0240		
85,000	.0275		
90,000	.0309		
95,000	.0338		
100,000	.0370		
105,000	.0405		
110,000	.0440		
115,000	.0488		
120,000	.0540		
140,000	.08		
160,000	.14		
190,000	.29		
216,000			Ultimate strength.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	37,180
Tensile strain on net section of upper plate	69,680
Compressive strain on bearing surface of rivets	39,780
Shearing strain on rivets	30,470

No. 737.—$\frac{5}{8}$″ Steel Plate. Set C . .

Duplicate of C . No. 736.
Upper plate, 9″.50 × ″.612.
Under plate, 9″.50 × ″.616.
1″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{1}{16}$″ diameter; die, $1\frac{5}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	5.81
Net sectional area of upper plate	3.10
Bearing surface of rivets	5.43
Shearing area of rivets	7.09

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0008		
20,000	.0021		
30,000	.0040		
40,000	.0068		
50,000	.0102		
60,000	.0150		
70,000	.0220		
80,000	.0280		
90,000	.0340		
100,000	.0420		
110,000	.0480		
130,000	.07		
160,000	.14		
175,000			Snapping sound heard.
208,000			Ultimate strength.

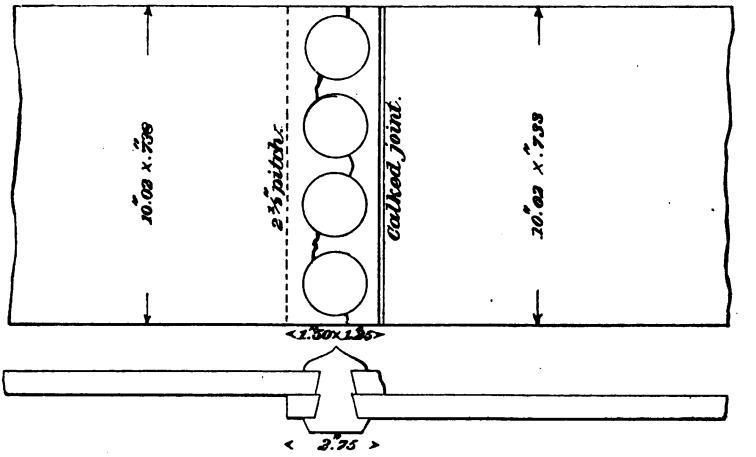
Fractured upper plate across line of rivet holes.
Fracture granular, radiating from rivet holes; metal not drawn down.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	35,800
Tensile strain on net section of upper plate	67,100
Compressive strain on bearing surface of rivets	38,300
Shearing strain on rivets	29,340

SINGLE AND DOUBLE RIVETED LAP JOINTS, ¼″ STEEL PLATE.

No. 726.—¾″ STEEL PLATE. SET A.



1⅛″ steel rivets, hand-driven.
Punched holes: Punch, 1 3/16″ diameter; die, 1 3/32 diameter.

	Square inches.
Gross sectional area of upper plate	7.39
Net sectional area of upper plate	3.75
Bearing surface of rivets	3.64
Shearing area of rivets	4.43

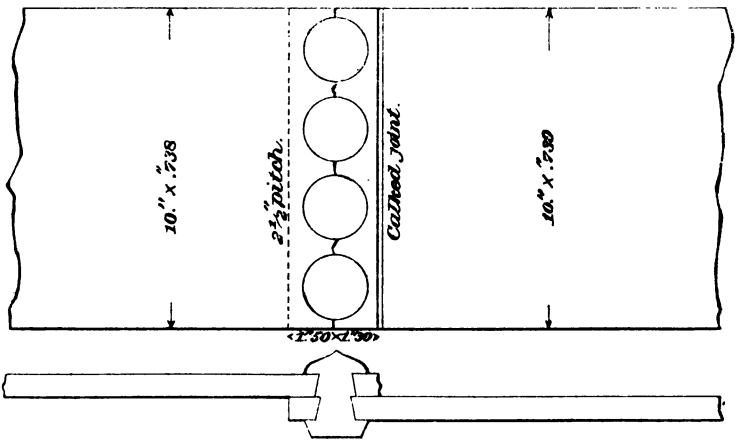
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0009		
30,000	.0020		
40,000	.0038		
50,000	.0090		
55,000	.0120		
60,000	.0150		
65,000	.0185		
70,000	.0220		
75,000	.0255		
90,000	.05		
100,000	.06		
110,000	.09		
120,000	.14		
130,000	.16		Sharp snapping sound heard.
140,000	.21		
149,900			Ultimate strength.

Fractured upper plate. Appearance of fractures granular, radiating from rivet holes without contraction of area except end section *A*, which is silky, and metal well drawn down.
Broke suddenly with loud report.
Lower plate bent to an angle of about 11°.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	20,280
Tensile strain on net section of upper plate	39,970
Compressive strain on bearing surface of rivets	41,180
Shearing strain on rivets	33,840

No. 727.—$\frac{3}{4}$″ STEEL PLATE. SET A..



$1\frac{1}{8}$″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{3}{16}$″ diameter; die, $1\frac{9}{32}$″ diameter.

	Square inches.
Gross sectional area of upper plate	7.38
Net sectional area of upper plate	3.73
Bearing surface of rivets	3.64
Shearing area of rivets	4.43

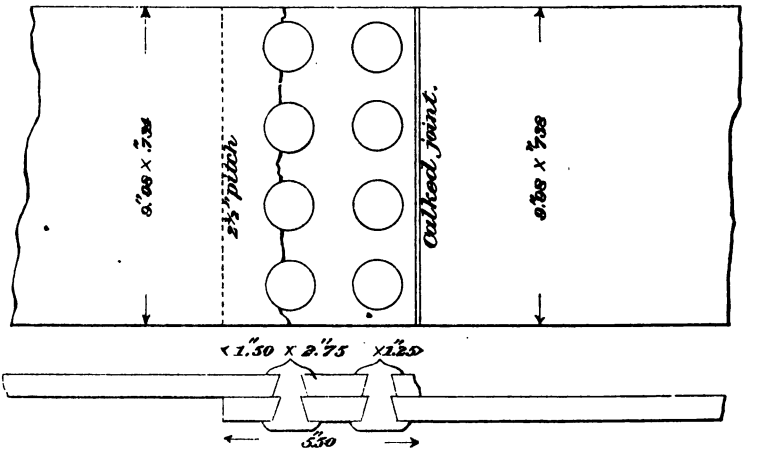
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0001	.....	
20,000	.0010	.....	
30,000	.0022	.....	
35,000	.0030	.....	
40,000	.0040	.....	
45,000	.0052	.....	
50,000	.0072	.....	
55,000	.0100	.....	
60,000	.0128	.....	
65,000	.0160	.....	
70,000	.0190	.....	
75,000	.0225	.....	
80,000	.0260	.....	
85,000	.0310	.....	
90,000	.0360	.....	
95,000	.0415	.....	
100,000	.0500	.....	
110,000	.09	.....	
120,000	.11	.....	
130,000	.15	.....	
140,000	.20	.....	
176,700	.....	.....	Ultimate strength.

Fractured upper plate. Broke suddenly with loud report. Metal granular.
No contraction of area.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	23,940
Tensile strain on net section of upper plate	47,370
Compressive strain on bearing surface of rivets	48,540
Shearing strain on rivets	39,890

No. 728.—$\frac{3}{4}$″ Steel Plate. Set C.



1⅛″ steel rivets, hand-driven.
Punched holes: Punch, $1\frac{3}{16}$″ diameter; die, $1\frac{9}{32}$ diameter.

	Square inches.
Gross sectional area of upper plate	7.33
Net sectional area of upper plate	3.70
Bearing surface of rivets	7.25
Shearing area of rivets	8.86

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0002		
20,000	.0011		
30,000	.0025		
40,000	.0040		
50,000	.0062		
60,000	.0092		
65,000	.0116		
70,000	.0135		
75,000	.0160		
80,000	.0182		
85,000	.0208		
90,000	.0240		
95.000	.0268		Joint open ″.01.
100,000	.0300		
120,000	.04		
140,000	.06		
160,000	.08		Snapping sound.
181,200			Ultimate strength.

Fractured upper plate, granular fractures radiating from rivet holes; hard appearance of metal next punched holes; metal not drawn down; exception, one end section has silky appearance, with metal well drawn down. Broke suddenly with loud report.

Lower plate bent about 5°.

Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of upper plate	24,720
Tensile strain on net section of upper plate	48,970
Compressive strain on bearing surface of rivets	24,990
Shearing strain on rivets	20,450

No. 729.—¾″ STEEL PLATE. SET C . .

Same style of joint as No. 728.
Upper plate, 10″ × ″.739.
Under plate, 10″ × ″.735.
1⅛″ steel rivets, hand-driven.
Punched holes: Punch, 1 3/16″ diameter; die, 1 9/32″ diameter.

	Square inches.
Gross sectional area of upper plate	7.39
Net sectional area of upper plate	3.74
Bearing surface of rivets	7.30
Shearing area of rivets	8.86

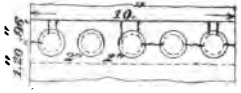
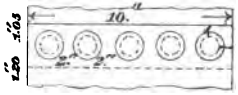
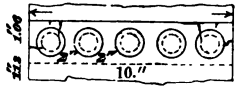
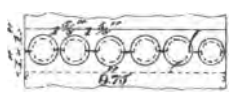
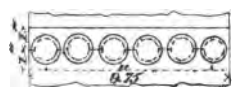
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0005		
20,000	.0018		
30,000	.0031		
40,000	.0050		
50,000	.0080		
55,000	.0102		
60,000	.0128		
65,000	.0150		
70,000	.0168		
75,000	.0188		
80,000	.0208		
85,000	.0230		
90,000	.0250		
95,000	.0280		
100,000	.0302		
120,000	.04		
140,000	.07		
160,000	.09		
177,700			Ultimate strength.

Fractured upper plate across row of rivet holes.
Fractures granular, radiating from rivet holes; four sections broke simultaneously; one end section broke last, at 170,000 pounds load; sharp snapping sound heard, the load falling slightly at the same time.

Maximum loads on joint.

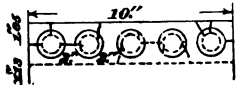
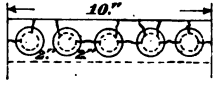
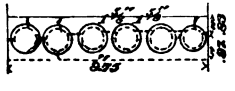
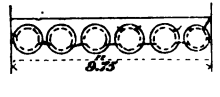
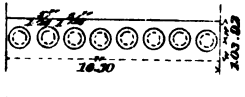
	Pounds per sq. inch.
Tensile strain on gross section of upper plate	24,050
Tensile strain on net section of upper plate	47,510
Compressive strain on bearing surface of rivets	24,340
Shearing strain on rivets	20,060

SINGLE-RIVETED LAP JOINTS, ¼″ IRON PLATE.

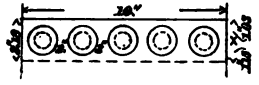
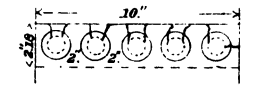
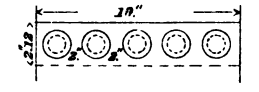
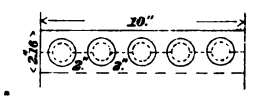
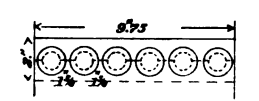
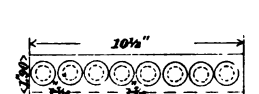
Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch. Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr. ct.*
35	A.		¼″ iron.	⅝″ iron rivets ..... / 1 1/16″ punched holes ..	2.425	1.55	.88	1.92	47,925	27,630	**43,230**	**76,140**	**34,900**	57.7
36	A..		¼″ iron.	⅝″ iron rivets ..... / 1 1/16″ punched holes ..	2.52	1.63	.895	1.92	47,925	29,444	**45,520**	82,910	**38,640**	61.4
37	C.		¼″ iron.	⅝″ iron rivets ..... / 1 1/16″ drilled holes	2.58	1.69	.89	1.87	47,925	25,270	**38,580**	73,260	**34,870**	52.8
38	C..		¼″ iron	⅝″ iron rivets ..... / 1 1/16 drilled holes	2.64	1.73	.911	1.87	47,925	27,380	**41,790**	79,360	**38,660**	57.1
39	D.		¼″ iron.	⅝″ iron rivets ..... / 1 1/16″ punched holes ..	2.66	1.48	1.18	2.31	47,925	29,020	**52,160**	65,420	33,420	60.6
40	D..		¼″ iron.	⅝″ iron rivets ..... / 1 1/16″ punched holes ..	2.65	1.48	1.18	2.31	47,925	30,680	**54,930**	68,890	35,200	64.0

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint it is indicated by employing larger type in more than one column.

SINGLE-RIVETED LAP JOINTS, ¼″ IRON PLATE—Continued.

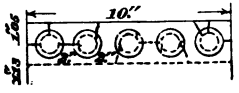
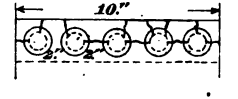
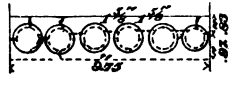
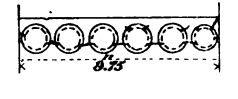
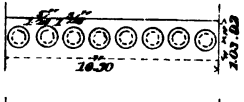
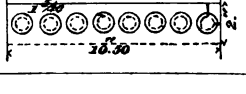
Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate.		Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.				Efficiency of joint.
					Gross.	Net.				Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs per sq. in.*					*Pr. ct.*
41	A A .		¼″ iron.	⅝″ steel rivets..... / 1 1/16″ punched holes...	2.41	1.54	.868	1.92	47,925	31,580	**49,420**	**87,670**	39,640	65.9
42	A A..		¼″ iron.	⅝″ steel rivets..... / 1 1/16″ punched holes ..	2.58	1.65	.929	1.92	47,925	30,220	**47,260**	**83,940**	40,610	63.1
43	D D .		¼″ iron	⅜″ steel rivets..... / ⅞″ punched holes ..	2.40	1.51	.886	1.53	47,925	28,875	**45,890**	**78,220**	45,300	60·3
44	D D..		¼″ iron.	⅜″ steel rivets..... / ⅞″ punched holes ..	2.36	1.49	.875	1.53	47,925	31,390	**49,720**	**84,660**	48,420	65.5
45	H .		¼″ iron.	⅞″ iron rivets ..... / ⅞″ drilled holes	2.73	1.69	1.04	1.57	47,925	25,440	41,095	66,778	**44,204**	53.1
46	H . .		¼″ iron.	⅞″ iron rivets ..... / ⅞″ drilled holes	2.85	1.76	1.084	1.57	47,925	23,158	**37,500**	60,886	**42,038**	48.3

SINGLE-RIVETED LAP JOINTS, ¼″ STEEL PLATE.

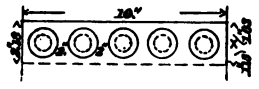
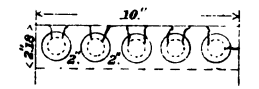
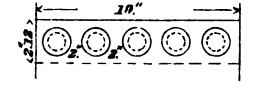
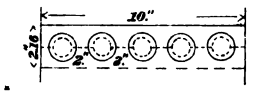
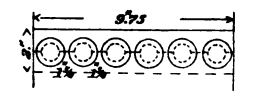
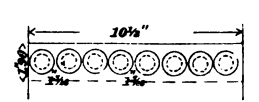
426	A .		¼″ steel	⅝″ iron rivets..... 1 1/16″ punched holes.	2.45	1.57	.882	1.92	55,765	29,690	46,340	82,480	**37,890**	53.2
427	A . .		¼″ steel	⅝″ iron rivets..... 1 1/16″ punched holes	2.47	1.58	.889	1.92	55,765	29,430	46,010	81,780	**37,860**	52.8
436	A A .		¼″ steel	⅝″ steel rivets . . 1 1/16″ punched holes.	2.45	1.57	.882	1.92	55,765	38,610	60.250	**107,260**	49,270	69.2
437	A A . .		¼″ steel	⅝″ steel rivets ..... 1 1/16″ punched holes.	2.47	1.58	.889	1.92	55,765	37,895	59,240	**105,290**	48,750	68.0
428	C .		¼″ steel	⅝″ iron rivets..... 1 1/16″ drilled holes...	2.53	1.66	.873	1.87	55,765	26,870	40,950	77,870	**36,350**	48.2
429	C . .		¼″ steel	⅝″ iron rivets..... 1 1/16″ drilled holes...	2.48	1.62	.856	1.87	55,765	27,680	42,370	80,200	**36,710**	49.6
438	C C .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.53	1.66	.873	1.87	55,765	41,460	**63,190**	120,160	56,100	74.3
439	C C . .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.45	1.60	.845	1.87	55,765	40,040	**61,310**	116,090	52,460	71.8
430	E .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.44	1.40	1.04	2.24	55,765	38,360	**66,860**	90,000	41,790	68.8
431	E . .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.44	1.40	1.04	2.24	55,765	40,160	**70,000**	94,230	43,750	72.0
47	H .		¼″ steel	7/16″ steel rivets.... ⅜″ drilled holes....	2.66	1.64	1.012	1.57	55,765	38,496	62,496	101,180	**65,220**	69.0

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint it is indicated by employing larger type in more than one column.

SINGLE-RIVETED LAP JOINTS, ¼″ IRON PLATE—Continued.

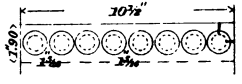
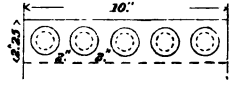
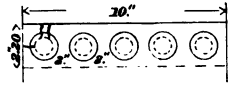
Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate.		Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.				Efficiency of joint.
					Gross.	Net.				Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	
					Sq. in.	*Sq. in.*	*Sq. in.*	*Sq. in.*	*Lbs per sq. in.*					*Pr. ct.*
41	A A .		¼″ iron.	⅝″ steel rivets..... ⅝″ punched holes...	2.41	1.54	.868	1.92	47,925	31,580	**49,420**	**87,670**	39,640	65.9
42	A A ..		¼″ iron.	⅝″ steel rivets..... ⅝″ punched holes ..	2.58	1.65	.929	1.92	47,925	30,220	**47,260**	**83,940**	40,610	63.1
43	D D .		¼″ iron	½″ steel rivets..... ⅝″ punched holes ..	2.40	1.51	.886	1.53	47,925	28,875	**45,890**	**78,220**	45,300	60·3
44	D D..		¼″ iron.	½″ steel rivets..... ⅝″ punched holes ..	2.36	1.49	.875	1.53	47,925	31,390	**49,720**	**84,660**	48,420	65.5
45	H .		¼″ iron.	⅞″ iron rivets ..... ⅛″ drilled holes	2.73	1.69	1.04	1.57	47,925	25,440	41,095	66,778	**44,204**	53.1
46	H . .		¼″ iron.	⅞″ iron rivets ..... ⅛″ drilled holes	2.85	1.76	1.084	1.57	47,925	23,158	**37,500**	60,886	**42,038**	48.3

SINGLE-RIVETED LAP JOINTS, ¼″ STEEL PLATE.

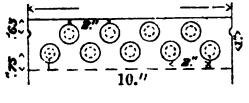
426	A .		¼″ steel	⅝″ iron rivets..... 1 1/16″ punched holes.	2.45	1.57	.882	1.92	55,765	29,690	46,340	82,480	**37,890**	53.2
427	A . .		¼″ steel	⅝″ iron rivets..... 1 1/16″ punched holes	2.47	1.58	.889	1.92	55,765	29,430	46,010	81,780	**37,860**	52.8
436	A A .		¼″ steel	⅝″ steel rivets . . 1 1/16″ punched holes.	2.45	1.57	.882	1.92	55,765	38,610	60.250	**107,260**	49,270	69.2
437	A A . .		¼″ steel	⅝″ steel rivets ..... 1 1/16″ punched holes.	2.47	1.58	.889	1.92	55,765	37,895	59,240	**105,290**	48,750	68.0
428	C .		¼″ steel	⅝″ iron rivets..... 1 1/16″ drilled holes...	2.53	1.66	.873	1.87	55,765	26,870	40,950	77,870	**36,350**	48.2
429	C . .		¼″ steel	⅝″ iron rivets..... 1 1/16″ drilled holes...	2.48	1.62	.856	1.87	55,765	27,680	42,370	80,200	**36,710**	49.6
438	C C .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.53	1.66	.873	1.87	55,765	41,460	**63,190**	120,160	56,100	74.3
439	C C . .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.45	1.60	.845	1.87	55,765	40,040	**61,310**	116,096	52,460	71.8
430	E .		¼″ steel	⅝″ steel rivets..... 1 1/16″ drilled holes...	2.44	1.40	1.04	2.24	55,765	38,360	**66,860**	90,000	41,790	68.8
431	E . .		¼″ steel	⅝″ steel rivets ..... 1 1/16″ drilled holes...	2.44	1.40	1.04	2.24	55,765	40,160	**70,000**	94,230	43,750	72.0
47	H .		¼″ steel	7/8″ steel rivets.... ½″ drilled holes....	2.66	1.64	1.012	1.57	55,765	38,496	62,496	101,180	**65,220**	69.0

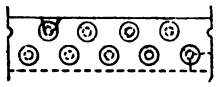
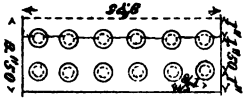
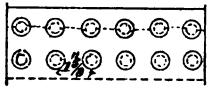
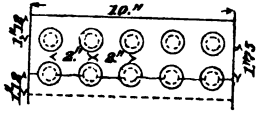
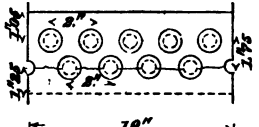
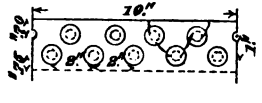
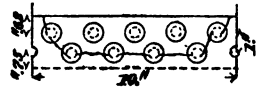
NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint it is indicated by employing larger type in more than one column.

SINGLE-RIVETED LAP JOINTS, ¼″ IRON PLATE—Continued.

Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch. Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr. ct.*
48	H . .		¼″ steel	⅞″ steel rivets ... ⅞″ drilled holes....	2. 625	1. 625	1. 00	1. 57	55, 765	36, 114	58, 338	94, 800	**60,382**	64. 8
49	CCC.		¼″ steel	⅝ steel rivets.... 11/16″ drilled holes...	2. 49	1. 63	. 856	1. 86	55, 765	39, 400	60, 184	114, 603	**52,742**	70. 6
50	CCC..		¼″ steel	⅝″ steel rivets .... 11/16″ drilled holes...	2. 50	1. 64	. 859	1. 86	55, 765	3 680	57, 439	109, 650	**50,645**	67. 8

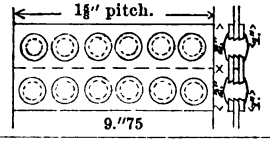
DOUBLE-RIVETED LAP JOINTS, ¼″ IRON AND STEEL PLATE.

85	I .		¼″ iron.	⅞″ iron rivets ..... 15/16″ drilled holes	2. 64	1. 98	1. 19	1. 77	47, 925	28, 900	38, 535	64, 120	**43,110**	60. 3

86	I . .		¼″ iron.	⅞″ iron rivets ..... ⅞″ drilled holes	2.36	1.77	1.06	1.77	47,925	31,314	**41,750**	**69,710**	**41,750**	65.3
617	K .		¼″ iron.	⅞″ iron rivets ..... ⅞″ punched holes ..	2.71	1.69	2.03	2.98	47,925	31,550	**50,592**	42,118	28,691	65.8
618	K . .		¼″ iron.	⅞″ iron rivets ..... ⅞″ punched holes ..	2.73	1.71	2.05	2.98	47,925	31,282	**49,950**	41,660	28,660	65.3
432	F .		¼″ steel	⅞″ iron rivets ..... ⅞″ punched holes ..	2.49	1.59	1.79	3.85	55,765	39,280	**61,510**	54,640	25,400	70.4
433	F . .		¼″ steel	⅞″ iron rivets ..... ⅞″ punched holes ..	2.54	1.63	1.83	3.85	55,765	38,700	**60,300**	53,715	25,530	69.4
434	G .		¼″ steel	⅞″ iron rivets ..... ⅞″ punched holes ..	2.52	1.61	1.63	3.46	55,765	41,785	**65,400**	64,600	30,430	74.9
435	G . .		¼″ steel	⅞″ iron rivets ..... ⅞″ punched holes ..	2.54	1.63	1.66	3.46	55,765	41,460	**64,600**	63,430	30,430	74.3
87	I .		¼″ steel	⅞″ steel rivets..... ⅞″ drilled holes	2.41	1.80	1.08	1.77	55,765	42,530	56,944	**94,910**	**57,910**	76.3
88	I . .		¼″ steel	⅞″ steel rivets..... ⅞″ drilled holes	2.44	1.83	1.10	1.77	55,765	44,344	**59,130**	98,360	61,130	79.5

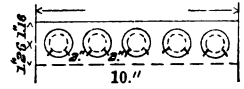
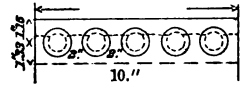
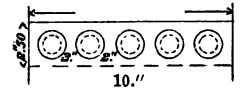
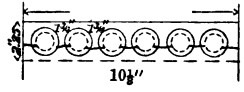
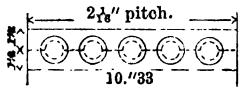
NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

DOUBLE-WELT BUTT JOINTS ¼″ IRON PLATE.

Number of test.	Distinguishing letter.	Style of joint.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.* Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
				Sq. inch.	*Sq. inch.*	*Sq. inch.*	*Sq. inch.*	*Lbs. per sq. inch.*					*Pr. ct.*
615	L.		⅝″ iron rivets. 1⅛″ punched holes	2.53	1.41	1.12	4.45	47,925	29,800	**53,475**	67,321	16,944	62.2
616	L..		.....do.....do	2.62	1.46	1.16	4.45	47,925	28,397	**50,959**	64,138	16,719	59.3

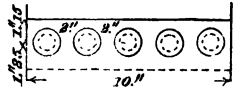
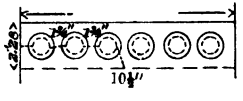
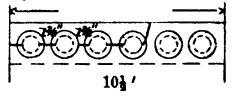
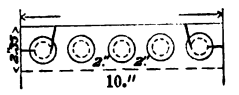
NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

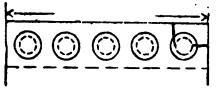
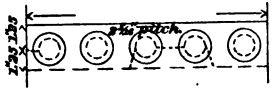
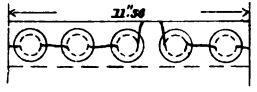
SINGLE-RIVETED LAP JOINTS, ⅜″ IRON PLATE.

Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.* Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs.per sq. in.*					*Pr. ct.*
62	A.		⅜″ iron.	1⅛″ iron rivets ¾″ punched holes	3.76	2.32	1.44	2.27	47,180	23 110	37,460	**60,340**	**38,280**	49.0
63	A..		⅜″ iron.	1⅛″ iron rivets ¾″ punched holes	3.81	2.35	1.46	2.39	47,180	22,280	**36,130**	**58,150**	35,520	47.2
64	C.		⅜″ iron.	1⅛″ iron rivets ¾″ drilled holes	3.73	2.29	1.44	2.33	47,180	23,445	38,190	60,730	**37,530**	49.7
65	C..		⅜″ iron	1⅛″ iron rivets ¾″ drilled holes	3.78	2.32	1.46	2.33	47,180	22,220	36,210	57 530	**36,050**	47.1
66	D.		⅜″ iron.	1⅛″ iron rivets ¾″ punched holes	3.95	2.23	1.72	2.72	47,180	23,570	**41,750**	54,130	34,230	50.0
67	D..		⅜″ iron.	1⅛″ iron rivets ¾″ punched holes	3.99	2.25	1.74	2.72	47,180	23,280	**41,290**	53,400	34,150	49.3
720	K.		⅜″ iron.	1″ iron rivets 1 1/16″ punched holes	4.07	1.88	2.19	4.43	47,180	28,500	**61,700**	52,970	26,180	60.4
721	K..		⅜″ iron.	1″ iron rivets 1 1/16″ punched holes	4.08	1.88	2.19	4.43	47,180	26,960	**58,510**	50,220	24,830	57.1

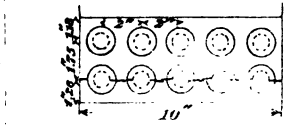
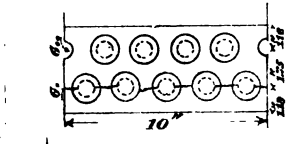
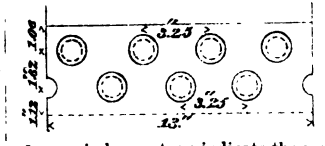
NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

SINGLE-RIVETED LAP JOINTS, ⅜″ STEEL PLATE.

Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.* Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr. ct.*
51	A.		⅜″ steel	1⅛″ iron rivets ¾″ punched holes	3.73	2.30	1.427	2.27	53,330	24,180	39,220	63,210	**39,740**	45.4
52	A..		⅜″ steel	1⅛″ iron rivets ¾″ punched holes	3.73	2.30	1.427	2.27	53,330	23,240	37,700	60,760	**38,190**	43.6
53	AA.		⅜″ steel	1⅛″ steel rivets ¾″ punched holes	3.75	2.32	1.43	2.27	53,330	34,160	55,215	**89,580**	**56,430**	64.1
54	AA..		⅜″ steel	1⅛″ steel rivets ¾″ punched holes	3.72	2.30	1.42	2.27	53,330	33,840	54,749	**88,660**	**55,460**	63.5
55	E.		⅜″ steel	1⅛″ steel rivets ¾″ drilled holes	3.97	2.22	1.746	2.79	53,330	35,590	**63,650**	80,930	**50,650**	66.7
56	E..		⅜″ steel	1⅛″ steel rivets ¾″ drilled holes	3.96	2.22	1.74	2.79	53,330	35,860	**63,976**	81,600	**50,900**	67.2
238	CC.		⅜″ steel	⅞″ steel rivets 1 1/16″ punched holes	3.74	2.16	1.58	2.64	53,330	37,810	65,460	**89,490**	**53,560**	70.9

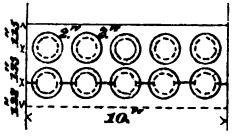
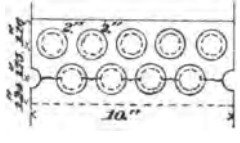
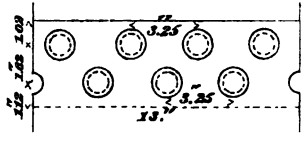
239	C C . .		⅜″ steel	⅞″ steel rivets ⅞″ punched holes	3.76	2.17	1.59	2.64	53,330	37,630	65,210	**88,990**	**53,600**	70.6
718	K .		⅜″ steel	1″ iron rivets 1 1/16″ punched holes	4.26	2.21	2.04	4.43	53,330	38,075	**73,394**	**79,510**	**36,614**	71.4
719	K . .		⅜″ steel	1″ iron rivets 1 1/16″ punched holes	4.22	2.19	2 02	4.43	53,330	38,390	**73,970**	**80,200**	36,590	72.0

DOUBLE-RIVETED LAP JOINTS, ⅜″ IRON AND STEEL PLATE.

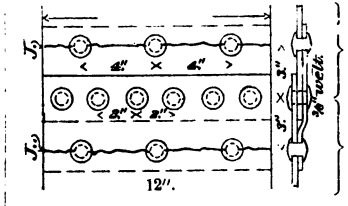
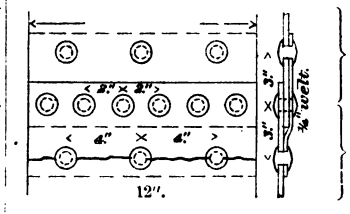
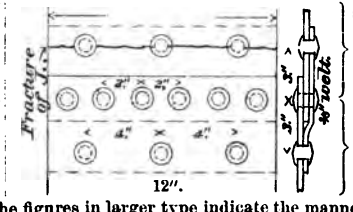
68	F .		⅜″ iron	1 1/16″ iron rivets ¾″ punched holes	3.75	2.32	2.87	4.54	47,180	29,970	**48,450**	39,160	24,760	63.5
69	F . .		⅜″ iron	1 1/16″ iron rivets ¾″ punched holes	3.79	2.34	2.89	4.54	47,180	31,320	**50,730**	41,070	26,150	66.4
58	F . . .		⅜″ iron	1 1/16″ iron rivets ¾″ punched holes	3.71	2.29	2.83	4.54	47,180	31,000	**50,220**	40,640	25,330	65.7
70	G .		⅜″ iron	1 1/16″ iron rivets ¾″ punched holes	3.94	2.43	2.71	4.08	47,180	28,530	**46,255**	41,480	27,550	60.5
71	G . .		⅜″ iron	1 1/16″ iron rivets ¾″ punched holes	3.87	2.39	2.67	4.08	47,180	28,475	**46,110**	41,270	27,010	60.4
81	I .		⅜″ iron	1 1/16″ iron rivets ¾″ drilled holes	5.09	3.91	2.06	3.08	47,180	23,750	30,920	58,700	**39,130**	50.4
82	I . .		⅜″ iron	1 1/16″ iron rivets ¾″ drilled holes	5.12	3.94	2.07	3.09	47,180	23,180	30,130	57,340	**38,410**	49.1

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in ore than one column.

DOUBLE-RIVETED LAP JOINTS, ⅜″ IRON AND STEEL PLATE—Continued.

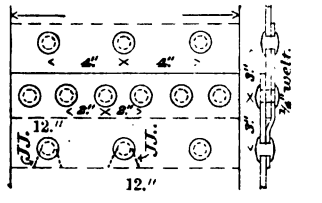
Number of tests.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch. Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr.ct.*
57	F.		⅜″ steel.	1⅛″ iron rivets ¾″ punched holes	3.76	2.32	2.89	4.54	53,330	39,020	**62,800**	50,760	32,310	73.2
59	F..		⅜″ steel.	1⅛″ iron rivets ¾″ punched holes	3.73	2.31	2.85	4.54	53,330	40,080	**64,720**	52,450	32,930	75.2
60	G.		⅜″ steel.	1⅛″ iron rivets ¾″ punched holes	3.63	2.24	2.49	4.08	53,330	39,010	**63,210**	56,860	34,710	73.2
61	G..		⅜″ steel.	1⅛″ iron rivets ¾″ punched holes	3.70	2.29	2.54	4.08	53,330	34,000	**54,930**	49,530	30,830	63.8
83	I.		⅜″ steel.	1⅛″ steel rivets ¾″ drilled holes	4.75	3.65	1.93	3.09	53,330	34,316	44,660	84,460	**52,750**	64.4
84	I..		⅜″ steel.	1⅛″ steel rivets ¾″ drilled holes	4.77	3.67	1.93	3.09	53,330	33,585	43,650	53,000	**51,845**	63.0

RIVETED JOINTS, ⅜″ IRON AND STEEL PLATE REINFORCED LAP JOINTS.

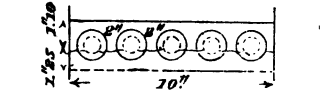
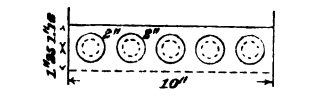
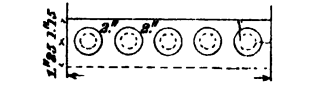
244	J .		⅜″ iron.	⅝″ iron rivets ..... .72 drilled holes	4.63	3.80	2.50	3.66	47,180	31,900	38,870	59,080	**40,360**	67.6
245	J . .		⅜″ iron.	⅝″ iron rivets ..... 1⅛″ drilled holes	4.69	3.74	2.89	4.75	47,180	34,900	**43,770**	56,640	34,460	74.0
296	J J .		⅜″ iron.	⅝″ iron rivets ..... 1⅛″ drilled holes	4.51	3.59	2.78	4.75	47,180	35,700	**44,840**	57,910	33,890	75.7
297	J J . .		⅜″ iron.	⅝″ iron rivets ..... 1⅛″ drilled holes ...	4.45	3.54	2.73	4.75	47,180	33,950	**42,680**	55,350	31,810	71.9
246	J .		⅜″ steel	⅝″ steel rivets..... 1⅛″ drilled holes	4.34	3.32	3.06	6.25	53,330	47,465	**62,050**	67,320	32,960	89.0
247	J . .		⅜″ steel	⅝″ steel rivets ..... 1⅛″ drilled holes	4.41	3.37	3.11	6.25	53,330	48,050	**62,880**	68,135	33,900	90.1

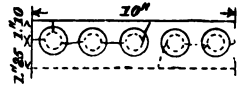
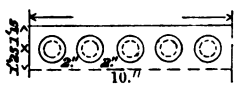
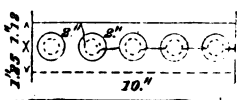
NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

RIVETED JOINTS, ⅜″ IRON AND STEEL PLATE REINFORCED LAP JOINTS—Continued.

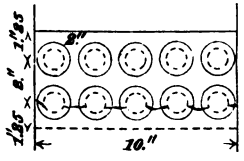
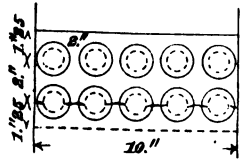
Number of tests.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch. Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq. in.	*Sq. in.*	*Sq. in.*	*Sq. in.*	*Lbs. per sq. in.*					*Pr. ct.*
298	J J.		⅜″ steel	⅞″ iron rivets ⅛″ drilled holes	4.47	3.43	3.11	6.11	53,330	46,820	61,020	**67,300**	**34,250**	87.8
299	J J..		⅜″ steel	⅞″ iron rivets ⅛″ drilled holes	4.48	3.44	3.12	6.11	53,330	47,390	61,710	**68,040**	**34,750**	88.9

SINGLE-RIVETED LAP JOINTS, ¼″ IRON AND STEEL PLATE.

240	A.		¼″ iron.	¾″ iron rivets ⅛″ punched holes.	5.095	2.91	2.18	2.64	44,615	17,760	**31,100**	41,500	34,280	39.8
241	A..		¼″ iron.	¾″ iron rivets ⅛″ punched holes.	5.14	2.94	2.20	2.64	44,615	17,690	**31,395**	41,955	34,960	39.7
292	A A.		¼″ iron.	¾″ iron rivets ⅛″ drilled holes	5.08	3.03	2.05	2.58	44,615	19,130	32,376	47,850	**38,020**	42.9
293	A A..		¼″ iron.	¾″ iron rivets ⅛″ drilled holes	5.12	3.05	2.07	2.58	44,615	19,765	33,180	48,890	**39,220**	44.3
327	A A A.		¼″ iron	¾″ steel rivets ⅛″ drilled holes	5.11	3.04	2.06	2.58	44,615	23,740	39,900	**58,880**	**47,020**	52.2

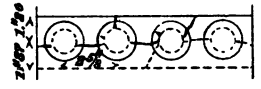
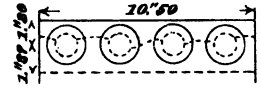
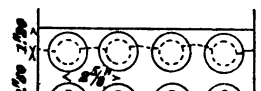
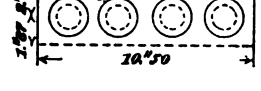
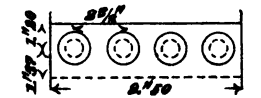
328	AAA..		½″ iron.	¾″ steel rivets..... ⅛″ drilled holes...	5.10	3.04	2.06	2.58	44,615	24,200	**40,590**	**59,900**	47,830	54.2
242	A .		½″ steel	¾″ iron rivets ..... ⅛″ punched holes.	4.97	2.84	2.13	2.64	57,215	21,830	38,204	50,940	**41,100**	38.2
243	A . .		½″ steel	¾″ iron rivets ..... ⅛″ punched holes.	4.97	2.84	2.13	2.64	57,215	20,523	35,915	47,890	**38,636**	35.9
294	A A .		½″ steel	⅛″ iron rivets .... 1″ punched holes .	4.93	2.40	2.536	3.93	57,215	29,310	**60,210**	56,980	**36,770**	51.2
295	AA . .		½″ steel	⅛″ iron rivets ... 1″ punched holes .	4.97	2.42	2.55	3.93	57,215	24,145	**49,590**	47,060	30,540	42.2

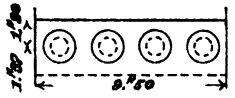
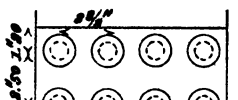
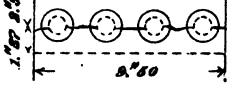
DOUBLE-RIVETED LAP JOINTS, ½″ IRON AND STEEL PLATE.

329	C .		½″ iron	¾″ iron rivets ..... ⅛″ punched holes	5.16	2.96	2.20	5.19	44,615	25,430	44,320	59,640	25,280	57.0
635	C . .		½″ iron	¾″ iron rivets .... ⅛″ punched holes.	5.17	2.97	2.20	5.19	44,615	24,060	42,920	57,950	24,560	55.2
619	C .		½″ steel	⅛ iron rivets .... 1″ punched holes .	5.02	2.39	5.26	7.85	57,215	30,757	**64,602**	29,354	19,670	53.8
620	C . .		½″ steel	⅛ iron rivets ..... 1″ punched holes..	5.01	2.39	5.25	7.85	57,215	30,778	**64,519**	29,371	19,644	53.8

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

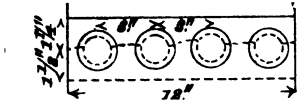
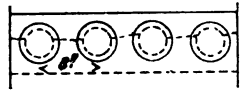
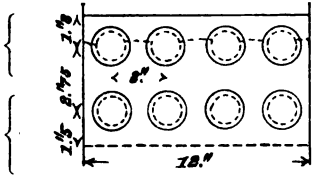
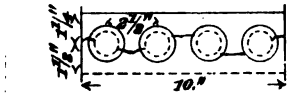
SINGLE AND DOUBLE RIVETED LAP JOINTS, ⅜″ IRON PLATE.

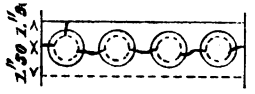
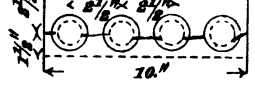
Number of test.	Distinguishing letter.	Style of joint.	Size of rivets and kind of holes.	Sectional area of plate.		Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch.				Efficiency of joint.
				Gross.	Net.				Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	
				Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr. ct.*
730	A.		1″ iron rivets 1 1/16″ punched holes	6.29	3.63	2.65	3.55	44,635	20,020	**34,680**	47,510	35,460	44.9
731	A..		1″ iron rivets 1 1/16″ punched holes	6.28	3.62	2.65	3.55	44,635	19,750	**34,230**	46,790	34,930	42.0
732	C.		1″ iron rivets 1 1/16″ punched holes	6.48	3.74	5.48	7.09	44,635	25,150	**43,580**	29,740	22,990	56.3
733	C..		1″ iron rivets 1 1/16″ punched holes	6.34	3.66	5.36	7.09	44,635	26,470	**45,850**	31,310	23,670	59.3
734	A.		1″ steel rivets 1 1/16″ punched holes	5.83	3.11	2.72	3.55	52,445	26,480	49,650	56,760	**43,490**	50.5

735	A . .		1″ steel rivets $1\frac{1}{16}$″ punched holes	5.82	3.10	2.72	3.55	52,445	28,110	53,770	60,150	**46,080**	58.6
736	C .		1″ steel rivets $1\frac{1}{16}$″ punched holes	5.81	3.10	5.43	7.09	52,445	37,180	**69,680**	39,780	80,470	70.9
737	C . .		1″ steel rivets $1\frac{1}{16}$″ punched holes	5.81	3.10	5.43	7.09	52,445	35,800	**67,100**	38,300	29,340	68.3

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

SINGLE AND DOUBLE RIVETED LAP JOINTS, ⅜″ IRON AND STEEL PLATE.

Number of test.	Distinguishing letter.	Style of joint.	Thickness of plate and kind of metal.	Size of rivets and kind of holes.	Sectional area of plate. Gross.	Sectional area of plate. Net.	Bearing surface of rivets.	Shearing area of rivets.	Tensile strength of metal.	Maximum strains on joint, pounds per square inch. Tension on gross area of plate.	Tension on net area of plate.	Compression on bearing surface of rivets.	Shearing on rivets.	Efficiency of joint.
					Sq.in.	*Sq.in.*	*Sq.in.*	*Sq.in.*	*Lbs. per sq. in.*					*Pr. ct.*
722	A.		⅜″ iron	1⅛″ iron rivets 1 3/16″ punched holes	8.38	4.93	3.44	4.43	46,590	17,230	29,290	41,980	32,600	37.0
723	A..		⅜″ iron	1⅛″ iron rivets 1 3/16″ punched holes	8.38	4.93	3.44	4.43	46,590	18,080	30,730	44,040	34,200	38.8
724	C.		⅜″ iron	1⅛″ iron rivets 1 3/16″ punched holes	8.41	4.95	6.92	8.86	46,590	24,720	42,000	30,040	23,460	53.1
725	C..		⅜″ iron	1⅛″ iron rivets 1 3/16″ punched holes	8.17	4.81	6.72	8.86	46,590	25,870	43,950	31,460	23,860	55.5
726	A.		⅜″ steel	1⅛″ steel rivets 1 3/16″ punched holes	7.39	3.75	3.64	4.43	51,545	20,280	39,970	41,180	33,840	39.3

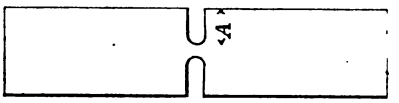
727	A . .		¾″ steel	1⅛″ steel rivets.....	7.38	3.73	3.64	4.43	51,545	28,940	47,270	48,540	39,890	46.4
				1 3/16″ punched holes.....										
728	C .		¾″ steel	1⅛″ steel rivets.....	7.33	3.70	7.25	8.86	51,545	24,720	48,970	24,990	20,450	48.0
				1 3/16″ punched holes.....										
729	C . .		¾″ steel ...	1⅛″ steel rivets.....	7.39	3.74	7.30	8.86	51,545	24,050	47,510	24,340	20,060	46.7
				1 3/16″ punched holes.....										

NOTE.—The figures in larger type indicate the manner of failure. When different kinds of fracture occurred in the same joint, it is indicated by employing larger type in more than one column.

Tensile tests of $\frac{1}{4}''$ iron and steel grooved specimens.

To determine the effect upon the tensile strength of the metal, of grooves, punched and drilled, varying in diameter, also varying the width of the specimens at the bottom of the grooves.

FORM OF SPECIMENS.



Each specimen reinforced by the same width of metal, $A=1''.10$, from the bottom of the groove to the side of the plate.

Diameters of drilled grooves: $\frac{1}{4}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$.

Diameters of punched grooves: Punch $\frac{9}{16}''$, die $\frac{5}{8}''$; punch $\frac{3}{4}''$, die die $\frac{13}{16}''$; punch $1''$, die $1\frac{1}{16}''$.

Tensile tests of $\frac{1}{4}''$ grooved specimen wrought iron.

Number.	Plate.	Diameter of groove.	Width at bottom of groove.	Thickness of plate.	Sectional area.	Ultimate strength. Actual pounds.	Ultimate strength. Pounds per sq. inch.	Remarks.
		Inch.	*Inch.*	*Inch.*	*Sq. in.*			
92	Punched...	$\frac{9}{16}$	.48	.240	.115	5,530	48,090	
93	....do	$\frac{5}{8}$	.46	.235	.108	5,070	46,940	
94	... do	$\frac{3}{4}$	.46	.241	.111	5,470	49,280	
95	... do	$\frac{3}{4}$	.49	.240	.118	6,530	55,340	
96	....do	1	.44	.239	.105	5,410	51,520	
97	....do	1	.47	.241	.113	5,640	49,910	
98	... do	$\frac{9}{16}$	.97	.247	.240	11,890	49,540	
99	....do	$\frac{9}{16}$	.98	.247	.242	12,090	49,960	
100	... do	$\frac{5}{8}$	.94	.249	.234	11,780	50,128	
101	....do	$\frac{5}{8}$	.96	.248	.238	11,160	46,900	
102	....do	1	.98	.250	.245	11,510	46,980	
103	....do	1	.96	.251	.241	11,170	46,350	
104	....do	$\frac{9}{16}$	1.47	.250	.368	13,850	37,636	
105	....do	$\frac{9}{16}$	1.50	.252	.378	14,110	37,326	
106	....do	$\frac{3}{4}$	1.48	.249	.369	15,140	41,030	
107	....do	$\frac{3}{4}$	1.48	.247	.366	14,450	39,480	
108	....do	1	1.47	.250	.368	13,780	37,446	
109	....do	1	1.45	.251	.364	14,390	39,533	
110	....do	$\frac{9}{16}$	1.96	.281	.551	23,800	43,194	
111	....do	$\frac{9}{16}$	1.95	.274	.534	25,360	47,490	
112	....do	$\frac{3}{4}$	1.95	.282	.550	22,750	41,360	
113	....do	$\frac{3}{4}$	1.92	.279	.536	23,090	43,080	
114	....do	1	2.03	.250	.508	20,900	41,140	
115	....do	1	1.99	.248	.494	19,550	39,575	
116	....do	$\frac{9}{16}$	2.42	.280	.678	24,550	36,210	
117	....do	$\frac{9}{16}$	2.40	.245	.588	24,840	42,245	
118	....do	$\frac{3}{4}$	2.47	.243	.600	25,340	42,233	
119	....do	$\frac{3}{4}$	2.46	.285	.601	25,670	42,712	
120	....do	1	2.48	.245	.608	23,180	38,125	
121	....do	1	2.44	.248	.605	25,180	41,620	
122	....do	$\frac{9}{16}$	2.97	.247	.734	28,600	38,964	
123	....do	$\frac{9}{16}$	2.98	.241	.718	29,800	41,540	
124	....do	$\frac{3}{4}$	2.96	.241	.713	28,500	39,972	
125	... do	$\frac{3}{4}$	2.92	.240	.701	29,240	41,712	
126	... do	1	2.98	.250	.745	30,120	40,430	
127	....do	1	2.95	.247	.729	29,780	40,850	

REMARKS.—The iron plates with punched and drilled grooves show that fractures began at the sides of the grooves for those specimens having a width of $1\frac{1}{2}''$, and wider before the metal separated at the middle of the specimen.

Fractures fibrous.

Tensile tests of ¼″ grooved specimen wrought iron.

Number.	Plate.	Diameter of groove.	Width at bottom of groove.	Thickness of plate.	Sectional area.	Ultimate strength. Actual pounds.	Ultimate strength. Pounds per sq. inch.	Remarks.
		Inch	*Inch.*	*Inch.*	*Sq. in.*			
128	Drilled	¼	.51	.249	.127	7,085	55,787	
129	do	¼	.52	.245	.127	7,100	55,905	
130	do	¼	.52	.275	.143	8,220	57,480	
131	do	¼	.52	.276	.144	8,060	56,000	
132	do	¼	.49	.248	.122	6,050	49,600	
133	do	¼	.50	.248	.124	7,030	56,700	
134	do	1	.47	.275	.129	7,080	54,880	
135	do	1	.51	.276	.141	8,150	57,800	
136	do	½	1.00	.276	.276	14,980	54,300	
137	do	¼	1.02	.273	.278	16,040	57,700	
138	do	¼	1.00	.276	.276	14,840	53,800	Seam developed half way across fracture.
139	do	¼	1.00	.280	.280	14,680	52,430	
140	do	¼	1.00	.252	.252	12,450	49,400	
141	do	¼	1.02	.275	.281	15,190	54,060	
142	do	1	1.01	.247	.249	13,140	52,770	
143	do	1	1.00	.278	.278	15,180	54,600	
144	do	¼	1.50	.276	.414	20,340	49,130	
145	do	¼	1.52	.273	.415	21,290	51,300	
146	do	¼	1.48	.251	.371	17,520	47,220	
147	do	¼	1.51	.273	.412	22,000	53,400	
148	do	¼	1.52	.275	.418	22,650	54,180	
149	do	¼	1.50	.276	.414	22,600	54,600	
150	do	1	1.48	.274	.406	22,840	56,250	
151	do	1	1.50	.249	.374	17,300	46,260	
152	do	¼	2.01	.275	.553	25,380	45,900	
153	do	¼	2.05	.279	.572	26,780	46,820	
154	do	¼	2.00	.275	.550	26,370	47,950	
155	do	¼	2.00	.278	.556	27,600	49,640	
156	do	¼	2.00	.286	.572	25,540	44,650	Open weld in rolling at fracture.
157	do	¼	2.00	.275	.550	27,930	50,780	
158	do	1	2.02	.279	.564	27,550	48,850	
159	do	1	2.00	.277	.554	27,610	49,840	
160	do	¼	2.51	.244	.612	27,530	44,980	
161	do	¼	2.52	.280	.706	28,350	40,150	
162	do	¼	2.51	.282	.708	30,550	43,150	
163	do	¼	2.50	.244	.610	27,760	45,500	
164	do	¼	2.51	.285	.715	33,240	46,500	Small open weld in rolling at fracture.
165	do	¼	2.49	.242	.603	29,860	49,520	
166	do	1	2.49	.242	.603	.....	.....	
167	do	1	2.50	.280	.700	31,350	44,780	
168	do	¼	3.02	.250	.755	34,500	45,700	
169	do	¼	3.02	.249	.752	33,740	44,870	
170	do	¼	3.00	.240	.720	33,670	46,760	
171	do	¼	3.00	.250	.750	34,280	45,700	
172	do	¼	2.93	.242	.709	34,000	47,950	
173	do	¼	2.99	.250	.748	36,460	48,740	
174	do	1	2.98	.279	.831	38,140	45,900	
175	do	1	3.01	.281	.846	37,570	44,410	

Tensile tests of ¼″ grooved specimens steel plate.

Number.	Plate.	Diameter of groove.	Width at bottom of groove.	Thickness of plate.	Sectional area.	Ultimate strength. Actual pounds.	Ultimate strength. Pounds per sq. inch.	Remarks.
		Inch	*Inch.*	*Inch.*	*Sq. in.*			
176	Punched	1/16	.49	.250	.123	8,010	65,120	
177	do	1/16	.47	.249	.117	7,840	67,010	
178	do	¼	.48	.249	.120	7,610	63,420	
179	do	¼	.48	.248	.119	7,920	66,550	
180	do	1	.48	.247	.119	7,980	67,060	
181	do	1	.47	.248	.117	7,640	65,300	
182	do	1/16	.99	.249	.246	14,720	59,840	
183	do	1/16	1.00	.250	.250	15,540	62,160	
184	do	¼	1.01	.249	.251	17,130	68,246	
185	do	¼	.96	.250	.240	16,160	67,330	
186	do	1	.96	.248	.238	15,700	65,966	
187	do	1	.95	.245	.233	14,610	62,700	
188	do	1/16	1.45	.248	.360	23,070	64,080	
189	do	¼	1.45	.252	.365	23,360	64,000	

Tensile tests of ¼″ grooved specimens steel plate—Continued.

Number.	Plate.	Diameter of groove.	Width at bottom of groove.	Thickness of plate.	Sectional area.	Ultimate strength. Actual pounds.	Ultimate strength. Pounds per sq. inch.	Remarks.
		Inch	*Inch.*	*Inch.*	*Sq. in.*			
190	....do	1	1.45	.249	.361	22,030	61,025	
191	....do	1	1.51	.251	.379	22,520	59,420	
192	....do	⅜	1.96	.250	.490	29,350	59,900	
193	... do	⅜	1.93	.252	.486	30,860	63,500	
194	....do	1	1.98	.250	.495	29,380	59,350	
195	... do	1	1.96	.251	.492	29,060	59,060	
196	....do	⅜	2.49	.249	.620	36,020	58,100	
197	... do	½	2.47	.249	.615	39,300	63,900	
198	....do	1	2.43	.250	.608	37,460	61,640	
199	... do	⅜	2.95	.251	.740	41,830	56,530	Specimen tore apart from one edge.
200	....do	⅜	3.01	.249	.749	44,030	58,780	
201	....do	½	3.04	.253	.769	42,680	55,500	
202	....do	½	2.97	.252	.748	44,920	60,060	
203	....do	1	2.98	.251	.748	40,430	54,050	
204	....do	1	2.97	.249	.740	41,470	56,040	

Above fractures, silky appearance. Specimens 1″ wide fracture at the sides of the groove before breaking at the center. The same remarks apply to all specimens above 1″ in width.

Specimens ½″ wide at bottom of groove break square across, leaving the fractured ends straight.

Tensile tests of ¼″ grooved specimens steel plate.

Number.	Plate.	Diameter of groove.	Width at bottom of groove.	Thickness of plate.	Sectional area.	Ultimate strength. Actual pounds.	Ultimate strength. Pounds per sq. inch.	Area at fracture.	Contraction of area.
		Inch.	*Inch.*	*Inch.*	*Sq. in.*				*Pr. ct.*
205	Drilled....	¼	.52	.246	.128	8,690	67,890		
206	....do	¼	.54	.248	.134	9,000	67,160	″.47×″.12=.056 square inch....	58.2
207	....do	¼	.53	.247	.131	8,760	66,870		
208	....do	¼	.50	.247	.123	8,070	65,610		
209	....do	¼	.51	.249	.127	8,430	66,370		
210	....do	¼	.51	.250	.128	8,630	67,420		
211	... do	1	.52	.248	.129	8,740	67,750		
212	....do	1	.52	.252	.131	8,110	61,910	″.41×″.12=.049 square inch....	62.6
213	....do	¼	1.03	.247	.254	17,040	67,090		
214	....do	¼	1.02	.250	.255	16,930	66,390	″.95×″.13=.124 square inch....	51.4
215	....do	¼	1.02	.246	.251	16,760	66,770		
216	....do	¼	1.02	.250	.255	17,270	67,730	″.92×″.13=.120 square inch....	53.0
217	....do	¼	1.01	.247	.249	16,440	66,020		
218	....do	¼	1.00	.251	.251	16,820	67,010	″.90×″.13=.117 square inch....	53.4
219	....do	1	1.00	.247	.247	15,920	64,450		
220	....do	1	1.01	.250	.253	16,720	66,090	″.89×″.13=.116 square inch....	54.1
221	....do	¼	1.54	.250	.385	24,790	64,390		
222	....do	¼	1.52	.251	.382	24,200	63,350		
223	....do	¼	1.50	.253	.380	24,460	64,370		
224	....do	1	1.54	.248	.382	24,790	64,895		
225	....do	½	2.02	.252	.509	32,740	64,320		
226	....do	½	2.00	.251	.502	31,610	62,970		
227	....do	1	2.02	.251	.507	30,880	60,910		
228	....do	½	2.50	.248	.620	36,740	59,260		
229	....do	½	2.50	.252	.630	39,850	63,250		
230	....do	1	2.53	.248	.627	37,240	59,390		
231	....do	¼	3.03	.251	.761	46,860	61,577		
232	....do	½	3.00	.249	.747	44,130	59,080		
233	....do	½	3.02	.251	.758	45,140	59,550		
234	....do	½	3.02	.250	.755	45,070	59,700		
235	....do	½	3.00	.250	.750	47,530	63,370		
236	....do	1	3.00	.251	.753	44,150	58,630		
237	....do	1	3.03	.252	.764	48,850	63,940		

Above fractures silky in appearance.

S. Ex. 1——face p. 145——2

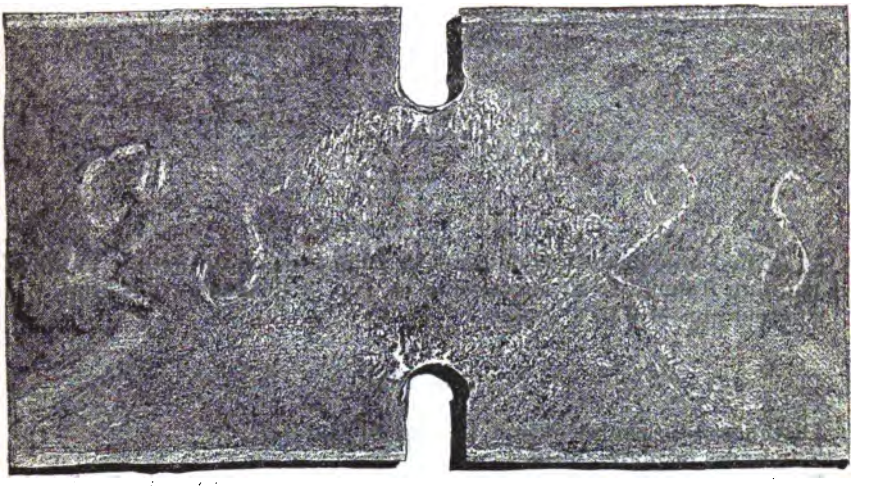
REMARKS.—Specimens with $\frac{1}{4}''$ groove 1″ wide fracture first at sides, thence tearing to the center of the part tested.

Specimens with $\frac{1}{2}''$ groove 1″ wide break square across, the fracture taking place at the same time over the full width.

Specimens with $\frac{3}{4}''$ groove fractured in the same manner as the $\frac{1}{2}''$ grooved ones.

Specimens with 1″ groove 1″ wide separate first at the middle.

Specimens 3″ wide all fractured irregular across plate, those with narrow grooves showing the greatest convexity of fractured ends.



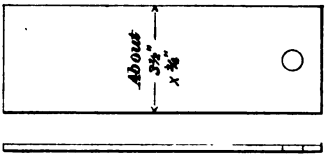
Photograph of grooved specimen, No. 229, showing the developement of "Cooper lines."

The test of this specimen was discontinued after the ultimate strength had been determined and before fracture took place.

Tests to determine the ultimate resistance of plate steel to tearing out at rivet holes.

¼″ STEEL PLATE.

Quality of metal from tensile test:
Elastic limit, 40,860 pounds per square inch.
Ultimate strength, 55,760 pounds per square inch.
Uniform elongation after fracture, 20 per cent.
Contraction of area at fracture, 56.5 per cent.
Appearance of fracture, silky.
Steel plate of ¼″ nominal thickness of the form shown by sketch.



⅝″ drilled hole spaced at distance *A* from the end of plate. Value of *A* running from 1″ to 2″, advancing by ¼″. 2 specimens of a kind.
⅝″ steel pin used in ⅝″ holes.

No. 469.

Distance from center of hole to edge of plate, 1″.
Thickness of plate, ″.246.
Diameter of hole × thickness = ″.625 × ″.246 = .154 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
3,500	.01	0.	Loads released to measure permanent elongation of hole.
5,000	No further change.		
7,000	.01+	About .00½	Color changes front of hole.
8,000	.02	.....	Color changes front of hole; wider strip covers.
9,000	.02½	.01	Scale starts front of hole.
10,000	.04	.02½	
12,000	.06	.05	
13,000	.08	.....	
14,000	.11	.10	Hole widens transversely about ″.00½.
15,000	.15	.....	
16,000	.27	.....	
16,150	.....	.34	Depth front of hole, ″.57, showing a reduction of ″.11.
16,200	.....	.....	Ultimate strength = 105,190 pounds per square inch on the compression area of hole.

Test discontinued before the metal separated front of hole, the permanent elongation of the hole having reached ″.48.

No. 470.

Duplicate of No. 469.
Thickness of plate, ″.250.
Diameter of hole × thickness (″.625 × .250) = .156 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
3,300	.00½	
4,200	.01	
8,800	.02	
10,500	.03	
12,000	.05	
13,000	.07	
14,000	.11	
15,000	.16	
16,380	.38	Ultimate strength = 105,000 pounds per square inch compression.

No. 471.

Thickness of plate, ———.
Distance from center of ⅝″ hole to end of plate, 1″.23.
Compression area, ″.250 × ″.625 = .156 square inch.
Micrometer dial applied for getting measurements.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
1,500	.0006	.....	
1,000	.....	.0001	
2,000	.0011	.....	
2,500	.0016	.....	
3,000	.0022	.....	
3,500	.0029	.....	
1,000	.....	.0010	
4,000	.0034	.....	
4,500	.0041	.....	
5,000	.0046	.....	
1,000	.....	.0011	
5,500	.0052	.....	
6,000	.0061	.....	
6,500	.0071	.....	
7,000	.0077	.....	
7,500	.0086	.....	
8,000	.0093	.....	
8,500	.0101	.....	
9,000	.0113	.....	
9,500	.0129	.....	
10,000	.0143	.....	
1,000	.....	.0082	
10,500	.0171	.....	
11,000	.0199	.....	
12,000	.0300	.....	
13,000	.043	.....	
14,000	.061	.....	
15,000	.083	.....	
16,000	.114	.....	
20,400	.....	.....	Ultimate strength = 130,770 pounds per square inch compression.

Fracture began at sides of hole.
Total elongation when maximum strain was reached, about ″.62

No. 472.

Duplicate of No. 471.
Thickness of plate, ″.249.
Distance from center of $\frac{5}{8}$″ hole to end of plate, 1″.29.
Compression area, .156 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
5,000	.0080	.....	
7,000	.0120	.....	
8,000	.0150	.....	
1,000	.....	.0100	
9,000	.0175	.....	
9,500	.019	.....	
10,000	.021	.....	
10,500	.023	.....	
11,000	.026	.....	
11,500	.030	.....	
12,000	.037	.....	
12,500	.044	.....	
13,000	.052	.....	
13,500	.060	.....	
14,000	.071	.....	
15,000	.096	.....	
20,180	.....	.....	Ultimate strength=129,360 pounds per square inch compression.

Fracture began at end of plate, front of hole, when elongation of hole had reached ″.57.

No. 473.

Thickness of plate, ″.250.
Distance from center of $\frac{5}{8}$″ hole to end of plate, 1″.51.
Compression area, .156 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
5,000	.0075	.....	
10,000	.0181	.....	
1,000	.....	.0125	
11,000	.0220	.....	
11,500	.0240	.....	
12,000	.0268	.....	
12,500	.0308	.....	
13,000	.034	.....	
13,500	.049	.....	
14,000	.047	.....	
14,500	.055	.....	
15,000	.064	.....	
15,500	.074	.....	
23,900	.....	.....	Ultimate strength=153,200 pounds per square inch compression.

No. 474.

Duplicate of No. 473.
Thickness of plate, ″.253.
Distance from center of hole to end of plate, 1″.51.
Compression area, .160 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	NOTE.—The shape of the specimen after fracture appears to indicate that the ultimate strength is somewhat lower than would be attained if the specimen was wider, so as to prevent the metal from widening the test piece at the end.
5,000	.0050	.....	
10,000	.0156	.....	
1,000	.....	.0096	
11,000	.0195	.....	
12,000	.0250	.....	
12,500	.0285	.....	
13,000	.0325	.....	
13,500	.0385	.....	
14,000	.0447	.....	
14,500	.0523	.....	
15,000	.0610	.....	
15,500	.0703	.....	
16,000	.0805	.....	
17,000	.1030	.....	
18,000	.131	.....	
19,000	.165	.....	
20,000	.208	.....	
21,000	.264	.....	
22,000	.346	.....	
24,700	.....	.....	Ultimate strength=154,370 pounds per square inch compression.

Failed the same as No. 473, by the metal front of the hole tearing apart.

No. 475.

Thickness of plate, ″.246.
Distance from center of hole to end of plate, 1″.75.
Compression area, .154 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
10,000	.0172	.....	
1,000	.....	.0118	
10,500	.0190	.....	
11,000	.0208	.....	
11,500	.0230	.....	
12,000	.0258	.....	
12,500	.0282	.....	
13,000	.0315	.....	
13,500	.0350	.....	
14,000	.0390	.....	
14,500	.0435	.....	
15,000	.0490	.....	
15,500	.0545	.....	
16,000	.0620	.....	
16,500	.0700	.....	
17,000	.0785	.....	
28,700	.....	.....	Ultimate strength=186,360 pounds per square inch compression.

Failed by tension at end of plate, front of hole, and also shearing at sides of hole.

Scale disturbed the full width (3½″) of the plate on either side of the hole.

No. 476.

Duplicate of No. 475.
Thickness of plate, ″.249.
Distance from center of hole to end of plate, 1″.73.
Compression area, 1.56 square inches.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
10,000	.0216	.....	
1,000	.....	.0158	
12,000	.0330	.....	
12,500	.0360	.....	
13,000	.0410	.....	
13,500	.0455	.....	
14,000	.0515	.....	
14,500	.0580	.....	
15,000	.0660	.....	
15,500	.0740	.....	
16,000	.0845	.....	
16,500	.0950	.....	
17,000	.1060	.....	
17,500	.1182	.....	
18,000	.1320	.....	
27,500	.....	.....	Ultimate strength=176,280 pounds per square inch compression.

Tore apart front of hole, fracture beginning at the end of the plate; sheared out piece, width about $\frac{5}{8}$″.

The manner of failure probably would have been different with a wider specimen, as this specimen widened at the end in a marked manner.

No. 477.

Thickness of plate, ″.248.
Distance from center of hole to end of plate, 1″.98.
Compression area, .155 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
10,000	.0162	.....	
1,000	.....	.0110	
12,000	.0252	.....	
12,500	.0282	.....	
13,000	.0315	.....	
13,500	.0350	.....	
14,000	.0390	.....	
14,500	.0435	.....	
15,000	.0480	.....	
15,500	.0530	.....	
16,000	.0590	.....	
16,500	.0650	.....	
17,000	.0712	.....	
17,500	.0788	.....	
18,000	.0870	.....	
18,500	.0968	.....	
19,000	.1080	.....	
31,800	.....	.....	Ultimate strength=205,160 pounds per square inch compression.

No. 478.

Duplicate of No. 477.
Thickness of plate, ".248.
Distance from center of $\frac{5}{8}$" hole to end of plate, 1".99.
Compression area, 1.55 square inches.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
10,000	.0222	.....	
1,000	.....	.0165	
12,000	.0330	.....	
13,000	.0400	.....	
13,500	.0445	.....	
14,000	.0490	.....	
14,500	.0550	.....	
15,000	.0600	.....	
15,500	.0662	.....	
16,000	.0738	.....	
16,500	.0820	.....	
17,000	.0915	.....	
17,500	.1015	.....	
18,000	.1120	.....	
31,050	.....	.....	Ultimate strength=200,320 pounds per square inch compression.

Details of riveted joints.

STEEL PLATES—PUNCHED HOLES.

Steel plates, from No. 469 to No. 478, inclusive, punched 11".16 holes for $\frac{5}{8}$" rivets through opposite end to that drilled.

The specimens were riveted together in pairs, and afterwards the rivet heads were planed off and the rivets driven out.

This leaves the punched holes in substantially the condition they are used in practice.

A steel pin, ".70 diameter, is used through the holes.

Punched holes in specimens Nos. 479 to 483, inclusive, and Nos. 401 to 405, inclusive.

No. 479.

Distance from center of hole to end of plate, 1″.05.
Diameter of hole, ″.71.
Thickness of plate, 2″.46.
Compression area, ″.246×″.70 = .172 square inch.
End of plate was sheared.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	.....	.....	
2,000	.0022	.....	
3,000	.0040	.....	
4,000	.0060	.....	
5,000	.0077	.....	
1,000	.....	.0042	
6,000	.0097	.....	
6,500	.0104	.....	
7,000	.0114	.....	
7,500	.0123	.....	
8,000	.0132	.....	
8,500	.0142	.....	
9,000	.0151	.....	
9,500	.0160	.....	
10,000	.0170	.....	
10,500	.0180	.....	
11,000	.0190	.....	
11,500	.0201	.....	
12,000	.0213	.....	
12,500	.0232	.....	
13,000	.0252	.....	
13,500	.0280	.....	
14,000	.0323	.....	
14,500	.0392	.....	
15,000	.0502	.....	
15,500	.0662	.....	
16,000	.1024	.....	
16,500	.1502	.....	
17,000	.2292	.....	
17,150	.3050	.....	Ultimate strength=99,710 pounds per square inch compression.

No. 480.

Distance from center of hole to end of plate, 1″.02.
End of plate planed.
Thickness of plate, ″.250.
Compression of area, .175 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0064	
8,000	.0100	
8,500	.0104	
9,000	.0112	
9,500	.0118	
10,000	.0124	
10,500	.0132	
11,000	.0139	
11,500	.0147	
12,000	.0155	
12,500	.0166	
13,000	.0180	
13,500	.0194	
14,000	.0214	
14,500	.0249	
15,000	.0322	
15,500	.0434	
16,000	.0594	
16,500	.0874	
17,000	.1374	
17,310	.2104	Ultimate strength = 98,910 pounds per square inch compression.

Sheared out plate in front of hole.

No. 481.

Distance from center of hole to end of plate, 1″.28.
End planed.
Thickness of plate, ″.250.
Compression area, .175 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0048	
8,000	.0070	
10,000	.0090	
11,000	.0101	
11,500	.0110	
12,000	.0119	
12,500	.0128	
13,000	.0138	
13,500	.0148	
14,000	.0162	
14,500	.0180	
15,000	.0205	
15,500	.0241	
16,000	.0298	
16,500	.0380	
17,000	.0482	
17,500	.0600	
18,000	.0755	
18,500	.0930	
19,000	.1158	
19,500	.1440	
20,000	.1790	
20,500	.1980	
20,800	.2670	
21,400	.....	Ultimate strength = 122,280 pounds per square inch.

Failed by shearing out front of hole.

No. 482.

Distance from center of hole to end of plate, 1″.26.
Sheared end to plate.
Skin planed off one side of plate at the hole about ″.003 deep.
Thickness of plate, ″.249.
Compression area, ″.246 × ″.70=.172 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0078	
8,000	.0120	
10,000	.0148	
11,000	.0161	
11,500	.0171	
12,000	.0181	
12,500	.0195	
13,000	.0210	
13,500	.0228	
14,000	.0250	
14,500	.0290	
15,000	.0348	
15,500	.0430	
16,000	.0540	
16,500	.0670	
17,000	.0850	
17,500	.1060	
18,000	.1330	
19,000	.2050	
19,780	.....	Ultimate strength = 115,000 pounds per square inch compression.

Failed in the same manner as No. 480. Its strength probably impaired by the slight strip planed off at side of hole.

No. 483.

Distance from center of hole to end of plate.
Planed end of specimen.
Thickness of plate, ″.250.
Compression area, .175 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0035	
10,000	.0085	
11,000	.0098	
11,500	.0105	
12,000	.0115	
12,500	.0123	
13,000	.0135	
13,500	.0146	
14,000	.0157	
14,500	.0172	
15,000	.0187	
15,500	.0209	
16,000	.0237	
16,500	.0277	
17,000	.0322	
17,500	.0387	
18,000	.0465	
19,000	.0687	
20,000	.0857	
21,000	.1127	
22,000	.1487	
23,000	.1917	
24,000	.2577	
24,820	.3790	Ultimate strength = 141,830 pounds per square inch compression.

Failed in the same manner as No. 480.

No. 401.

Distance from center of hole to end of plate, 1″.49.
Planed end of specimen.
Thickness of plate, 2″.53.
Compression area, .177 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0038	
10,000	.0090	
11,000	.0101	
12,000	.0115	
12,500	.0121	
13,000	.0130	
13,500	.0140	
14,000	.0150	
14,500	.0160	
15,000	.0178	
15,500	.0192	
16,000	.0212	
16,500	.0240	
17,000	.0272	
17,500	.0315	
18,000	.0378	
19,000	.0540	
20,000	.0780	
21,000	.0980	
22,000	.1330	
23,000	.1730	
24,000	.2460	
24,350	.3110	Ultimate strength = 137,570 pounds per square inch compression.

Failed same as No. 480.

No. 402.

Distance from center of hole to end of plate, 1″.75.
Planed end of plate.
Thickness of plate, ″.246.
Compression area, ″.172 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0084	
10,000	.0160	
12,000	.0196	
12,500	.0206	
13,000	.0216	
13,500	.0227	
14,000	.0240	
14,500	.0254	
15,000	.0270	
15,500	.0287	
16,000	.0306	
16,500	.0334	
17,000	.0363	
17,500	.0393	
18,000	.0445	
18,500	.0506	
19,000	.0575	
19,500	.0665	
20,000	.0755	
21,000	.0965	
22,000	.1205	
23,000	.1480	
24,000	.1810	
25,000	.2130	
26,000	.2680	
26,500	.3190	Ultimate strength = 154,070 pounds per square inch compression.

Failed the same as No. 480.

No. 403.

Distance from center of hole to end of plate, 1″.76.
Plate sheared across end.
Thickness of plate, ″.249.
Compression area, ″.174 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0158	
10,000	.0195	
12,000	.0220	
12,500	.0228	
13,000	.0238	
13,500	.0249	
14,000	.0261	
14,500	.0280	
15,000	.0300	
15,500	.0325	
16,000	.0355	
16,500	.0410	
17,000	.0470	
17,500	.0532	
18,000	.0605	
18,500	.0690	
19,000	.0788	
19,500	.0900	
20,000	.1025	
21,000	.1295	
22,000	.1600	
23,000	.1930	
24,000	.2360	
25,000	.2820	
25,900	.3820	Ultimate strength = 148,850 pounds per square inch compression.

Failed in the same manner as No. 480.

No. 404.

Thickness of plate, ″.248.
Average diameter of punched hole (″.70 + ″.78) = ″.74.
Distance from center of hole to end of plate, 2″.
The end of the specimen is planed.
Compression area, ″.174 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0081	
10,000	.0192	
12,000	.0236	
13,000	.0261	
13,500	.0279	
14,000	.0296	
14,500	.0310	
15,000	.0331	
15,500	.0352	
16,000	.0380	
16,500	.0409	
17,000	.0436	
17,500	.0470	
18,000	.0515	
18,500	.0550	
19,000	.0625	
19,500	.0698	
20,000	.0778	
20,500	.0872	
21,000	.0961	
22,000	.1208	
23,000	.1455	
24,000	.1700	
25,000	.2060	
28,900	.3770	
29,200	.....	Ultimate strength = 167,820 pounds per square inch compression.

Failed same as No. 480. Appearance of fracture silky.

No. 405.

Thickness of plate, ″.248.
Diameter of punched holes: Punch side, ″.77; die side, ″.81; average diameter, ″.79.
Same pin used as before, ″.70 diameter.
Distance from center of hole to end of plate, 2″.05.
Plate planed across end.
Compression area, .174 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0095	
10,000	.0240	
12,000	.0320	
14,000	.0420	
15,000	.0480	
15,500	.0515	
16,000	.0549	
16,500	.0590	
17,000	.0620	
17,500	.0662	
18,000	.0710	
18,500	.0756	
19,000	.0812	
19,500	.0889	
20,000	.0962	
21,000	.1140	
22,000	.1340	
23,000	.1618	
24,000	.1895	
25,000	.2228	
30,980	.....	Ultimate strength=178,050 pounds per square inch compression.

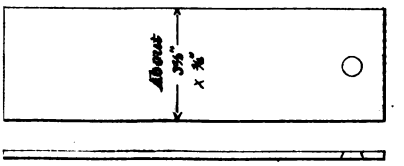
Failed the same as No. 480.

Details of riveted joints.

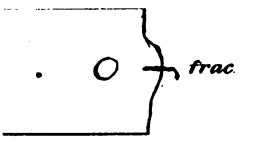
¼″ Steel Plate—Punched Holes.

Resistance of plates to tearing out punched holes; ⅝″ punched holes plates not riveted.
Holes varying from 1″ to 2″ from end of plates.

FORM OF SPECIMENS.



Holes punched: Punch side, ″.64 diameter; die side, ″.70 diameter.
Pin used in punched holes, ⅝″ diameter.
Sheared ends.

Number of test.	Distance from center of hole to end of plate.	Thickness of plate.	Compression area. Diameter of pin × thickness of plate.	Ultimate resistance.		Remarks.
				Actual pounds.	Pounds per square inch on compression area.	
	Inches.	*Inch.*	*Sq. in.*			
406	1.00	.246	.154	15,770	102,400	
407	1.04	.248	.155	16,990	109,600	
408	1.27	.245	.153	19,780	129,300	
409	1.27	.245	.153	20,270	132,500	Fractures all began at sheared ends, as shown above.
410	1.50	.246	.154	21,900	142,200	
411	1.50	.247	.154	23,210	150,700	
412	1.74	.246	.154	25,390	164,900	
413	1.72	.247	.154	25,490	165,500	
414	2.00	.243	.152	27,830	183,100	
415	1.99	.245	.153	29,300	191,500	

Above specimens, Nos. 406 to 415, inclusive, prepared with $\frac{11}{16}''$ drilled holes through opposite ends.

Same $\frac{5}{8}''$ pin used as before.

$\frac{1}{4}''$ STEEL PLATE, $\frac{11}{16}''$ DRILLED HOLES.

SHEARED ENDS.

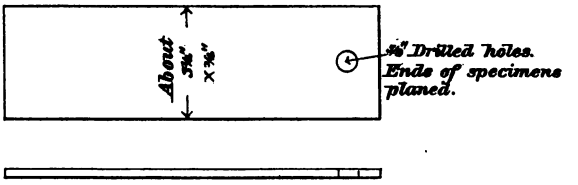
Number of test.	Distance from center of hole to end of plate.	Thickness of plate.	Compression area. Diameter of pin × thickness of plate.	Ultimate resistance.		Remarks.
				Actual pounds.	Pounds per square inch on compression area.	
	Inches.	*Inch.*	*Sq. in.*			
416	1.00	.252	.158	15,800	100,000	Fractures all began at sheared end, except No. 424, which began at the holes.
417	1.00	.246	.154	16,100	104,500	
418	1.25	.247	.154	19,430	126,200	
419	1.25	.244	.153	18,970	124,000	
420	1.59	.246	.154	21,850	141,900	
421	1.50	.244	.153	21,550	140,850	
422	1.77	.245	.153	23,900	156,200	
423	1.78	.250	.156	27,890	178,800	
424	2.02	.246	.154	28,470	184,900	
425	2.03	.245	.153	28,800	188,200	

WROUGHT-IRON PLATE.

(Tests to determine the ultimate resistance of iron plate to tearing out at the rivet holes.)

$\frac{5}{8}$" DRILLED HOLES.

SHAPE OF SPECIMENS.



No. 445.

Thickness of plate, ".241.
From center of hole to end of plate, ".99.
Compression area of hole ".625 × ".241 = .151 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of hole.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	.....	.....	
5,000	.0065	.....	
1,000	.....	.0035	
6,000	.0088	.....	
7,000	.0115	.....	
8,000	.0165	.....	
9,000	.0248	.....	
9,500	.0308	.....	
10,000	.0398	.....	
10,250	About .09	.....	Ultimate strength = 67,880 pounds per square inch on compression area of holes.

Failed by developing a fracture at end of plate, where metal was under tensile strain. Fracture then extended towards drilled hole.

No. 446.

Duplicate of No. 445.
Thickness of plate, ".244.
Distance from center of hole to end of plate, 1".
Compression area of hole, ".625 × ".244 = .153 square inch.

Loads applied.	Elongation of hole.	Permanent elongation of holes.	Remarks.
Pounds.	*Inch.*	*Inch.*	
1,000	0.	.....	
5,000	.0060	.....	
1,000	.....	.0028	
6,000	.0071	.....	
6,500	.0080	.....	
7,000	.0090	.....	
7,500	.0100	.....	
8,000	.0118	.....	
8,500	.0140	.....	
9,000	.0176	.....	
9,500	.0220	.....	
10,000	.0265	.....	
10,500	.0345	.....	
11,000	.0480	.....	
11,280	.0630	.....	Ultimate strength = 73,720 pounds per square inch on compression area.

Test continued after passing the ultimate resistance, developing fractures on either side of the hole.

The initial fracture began at the end of the plate, reaching back to the hole.

No. 447.

Compression area, ″.625 × ″.245 = .153 square inch.
Thickness of plate, ″.245.
Distance from center of $\frac{5}{8}$″ hole to end of plate, 1″.25.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000		
2,000	.0020	
3,000	.0036	
4,000	.0055	
5,000	.0071	
6,000	.0086	
6,500	.0096	
7,000	.0106	
7,500	.0118	
8,000	.0135	
8,500	.0150	
9,000	.0168	
9,500	.0189	
10,000	.0215	
10,500	.0244	
11,000	.0296	
11,500	.0355	
12,000	.0430	
12,500	.0535	
12,720	.0705	Ultimate strength = 83,140 pounds per square inch on compression area.

Failed same as specimen No. 445..

No. 448.

Duplicate of No. 447.
Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.22.
Compression area, ″.625 × ″.243 = .152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0070	
6,000	.0090	
6,500	.0100	
7,000	.0109	
7,500	.0118	
8,000	.0128	
8,500	.0142	
9,000	.0161	
9,500	.0182	
10,000	.0210	
10,500	.0245	
11,000	.0290	
11,500	.0342	
12,000	.0410	
12,500	.0500	
13,000	.0810 .0880	Ultimate strength = 85,530 pounds per square inch on compression area.

Failed same as No. 445.

No. 449.

Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.50.
Compression area, ″.625 × ″.243 = .152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	.....	
5,000	.0042	
6,000	.0053	
6,500	.0063	
7,000	.0073	
7,500	.0083	
8,000	.0093	
8,500	.0107	
9,000	.0122	
9,500	.0142	
10,000	.0162	
10,500	.0187	
11,000	.0217	
11,500	.0247	
12,000	.0287	
12,500	.0332	
13,000	.0392	
13,500	.0460	
14,000	.0537	
15,510	.0992	Ultimate strength = 102,040 pounds per square inch on compression.

Failed same as No. 445.

No. 450.

Duplicate of No. 449.
Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.50.
Compression area, .152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0049	
6,000	.0060	
7,000	.0078	
7,500	.0089	
8,000	.0100	
8,500	.0112	
9,000	.0130	
9,500	.0151	
10,000	.0175	
10,500	.0208	
11,000	.0239	
11,500	.0275	
12,000	.0321	
12,500	.0380	
13,000	.0450	
13,500	.0520	
14,000	.0610	
15,000	.0810	
15,780	.1180	Ultimate strength = 103,820 pounds per square inch compression.

Fractured same as No. 445.

¼″ plates Nos. 445 to 450, inclusive, that have been tested with drilled holes, now prepared with punched holes through opposite ends, punched and riveted together in pairs with ⅝″ iron rivets. The rivet heads were planed off and the rivets driven out.

It is found that these machine-driven rivets produce serious injury to the plates. When the hole was within 1½″ of the edge the plates were burst by the rivets, starting fractures at the edge of the plate.

While the plates in this condition, with fracture already developed, will fail to give the comparative strength of drilled and punched holes, the results will probably give an indication of the strength of riveted joints in iron plates that have been weakened in this same manner.

Specimens Nos. 451 to 456, inclusive, have punched holes. Size of punch, $\frac{11}{16}$″ diameter; die, $\frac{3}{4}$″ diameter.

Diameter of pin used in punched holes, ″.70.

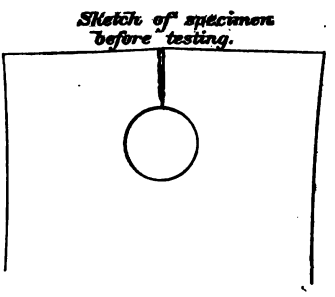
No. 451.

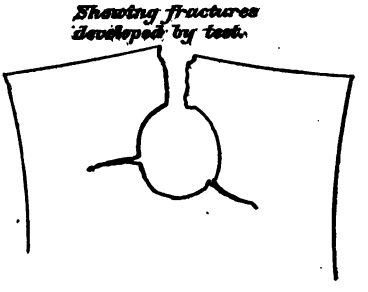
Thickness of plate, ″.241.

Distance from center of hole to end of plate, 1″.

Compression area ″.241 × ″.70 = .1687 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0215	
6,000	.0275	
7,000	.0328	
8,000	.0410	
8,250	.....	Ultimate strength = 48,900 pounds per square inch compression.





No. 452.

Thickness of plate, ″.244.

Distance from center of whole to end of plate, 1″.

Compression area ″.244 × ″.70 = .171 square inch.

8,100 pounds ultimate strength = 47,370 pounds per square inch compression.

Fracture started same as in No. 451.

Afterwards developed fractures at sides of hole.

No. 453.

Thickness of plate, ″.245.

Distance from center of hole to end of plate, 1″.25.

Compression area, ″.245 × ″.70 = .172 square inch.

11,200 pounds ultimate strength = 65,120 pounds per square inch compression.

Fracture at end of plate about 4″ long, reaching back towards hole.

End of specimen sheared.

Failed by opening initial fracture and a fracture at side of hole.

No. 454.

Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.20.
Compression area, ″.243 × ″.70 = .17 square inch.
Fracture in end of plate caused by riveting similar to No. 453.
12,500 pounds ultimate strength = 73,530 pounds per square inch compression.

No. 455.

Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.47.
Compression area, ″.243 × ″.70 = .170 square inch.
Punched hole about ″.02 larger in diameter than the punch and die used.
No fracture in sight caused by riveting.
End of plate sheared.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0082	
10,000	.0206	
10,500	.0215	
11,000	.0230	
11,500	.0248	
12,000	.0268	
12,500	.0289	
13,000	.0310	
13,500	.0339	
14,000	.0380	
14,500	.0439	
15,000	.0530	
15,150	.0570	Ultimate strength = 89,120 pounds per square inch compression.

Fracture began at end of plate.

No. 456.

Thickness of plate, ″.243.
Distance from center of hole to end of plate, 1″.47.
End of plate planed.
Compression area, ″.243 × ″.70 = .170 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0070	
8,000	.0139	
10,000	.0188	
10,500	.0201	
11,000	.0218	
11,500	.0235	
12,000	.0255	
12,500	.0280	
13,000	.0305	
13,500	.0335	
14,000	.0372	
14,500	.0410	
15,000	.0460	
15,500	.0515	
16,000	.0605	
16,300	.0750	Ultimate strength = 95,900 pounds per square inch compression.

Failed by opening a fracture at the end of the plate.

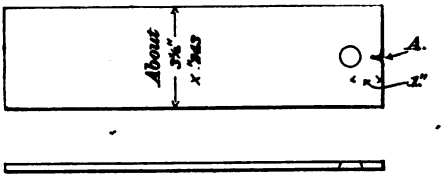
Nos. 457 to 462, inclusive.

½″ plates having ⅝″ punched holes. Punch, ″.64 diameter; die, ″.71 diameter.

Plates did not have rivets driven. Ends planed.

Diameter of pin used in punched holes, ⅝″.

No. 457.



Compression area, ″.243×″.625=.152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
3,000	.0090	
5,000	.0182	
5,500	.0205	
6,000	.0230	
6,500	.0251	
7,000	.0285	
7,500	.0318	
8,000	.0358	
8,500	.0405	
9,000	.0450	
9,000	.0468	After twelve minutes rest.
9,500	.0528	
10,000	.0608	
10,500	.0718	
11,000	.1000	Ultimate strength=72,370 pounds per square inch compression.

Fracture began at end of plate at *A*.

No. 458.

Duplicate of No. 457.

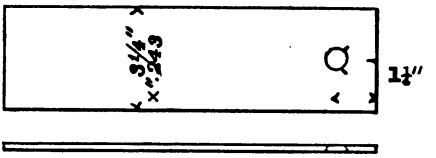
Distance from center of hole to end of plate, 1″.

Compression area, ″.241×″.625=.151 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0211	
5,500	.0232	
6,000	.0260	
6,500	.0288	
7,000	.0310	
7,500	.0340	
8,000	.0370	
8,500	.0408	
9,000	.0440	
9,500	.0490	
10,000	.0558	
10,500	.0620	
11,000	.0720	
11,500	.0840	
11,860	.0990	Ultimate strength=78,540 pounds per square inch compression.

Fracture began at end of plate same as No. 457.

No. 459.



Compression area, ".243×".625=.152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0085	
5,500	.0102	
6,000	.0121	
6,500	.0140	
7,000	.0161	
7,500	.0185	
8,000	.0210	
8,500	.0235	
9,000	.0260	
9,500	.0300	
10,000	.0340	
10,500	.0395	
11,000	.0461	
11,500	.0530	
12,000	.0625	
12,500	.0728	
13,000	.0850	
13,440	.1040	Ultimate strength=88,420 pounds per square inch compression.

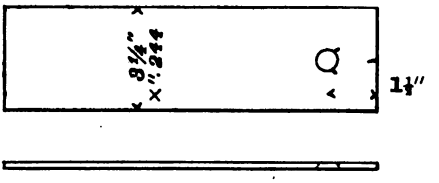
Fracture began at end of plate and at sides of hole.

No. 460.

Duplicate of No. 459.
Thickness of plate, ".243.
Compression area, ".243×".625=.152 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0095	
6,000	.0140	
7,000	.0185	
7,500	.0208	
8,000	.0230	
8,500	.0259	
9,000	.0288	
9,500	.0320	
10,000	.0375	
10,500	.0420	
11,000	.0490	
11,500	.0570	
12,000	.0653	
12,500	.0748	
13,000	.0888	Ultimate strength=85,520 pounds per square inch compression.

No. 461.



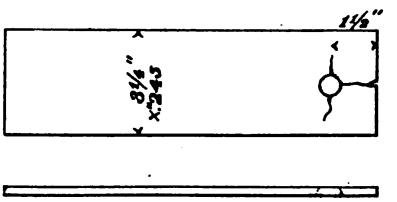
Compression area, ".244×".625 = .153 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0110	
6,000	.0142	
7,000	.0170	
8,000	.0208	
8,500	.0230	
9,000	.0252	
9,500	.0280	
10,000	.0310	
10,500	.0340	
11,000	.0380	
11,500	.0410	
12,000	.0470	
12,500	.0515	
13,000	.0575	
13,500	.0640	
15,500	.....	Ultimate strength = 101,310 pounds per square inch compression.

Test discontinued soon as maximum load was passed.
Fractures started at edge of plate, also at sides of punched hole.

No. 462.

Duplicate of No. 461.



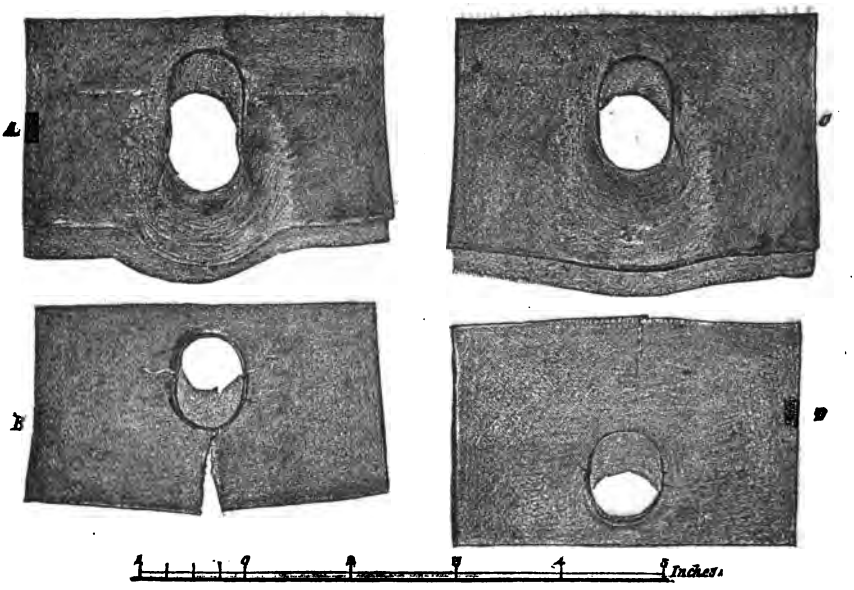
Compression area ".245×".625 = .153 square inch.

Loads applied.	Elongation of hole.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
5,000	.0175	
6,000	.0208	
7,000	.0250	
8,000	.0295	
8,500	.0318	
9,000	.0340	
9,500	.0368	
10,000	.0390	
10,500	.0428	
11,000	.0465	
11,500	.0502	
12,000	.0550	
12,500	.0605	
13,000	.0670	
13,500	.0742	
14,000	.0830	
14,500	.0938	
15,000	.1070	
15,500	.1260	
15,745	.1490	Ultimate strength = 102,910 pounds per square inch compression.

Fractures developed as shown by sketch.

Resistance of steel and iron plates to tearing out at rivet holes.

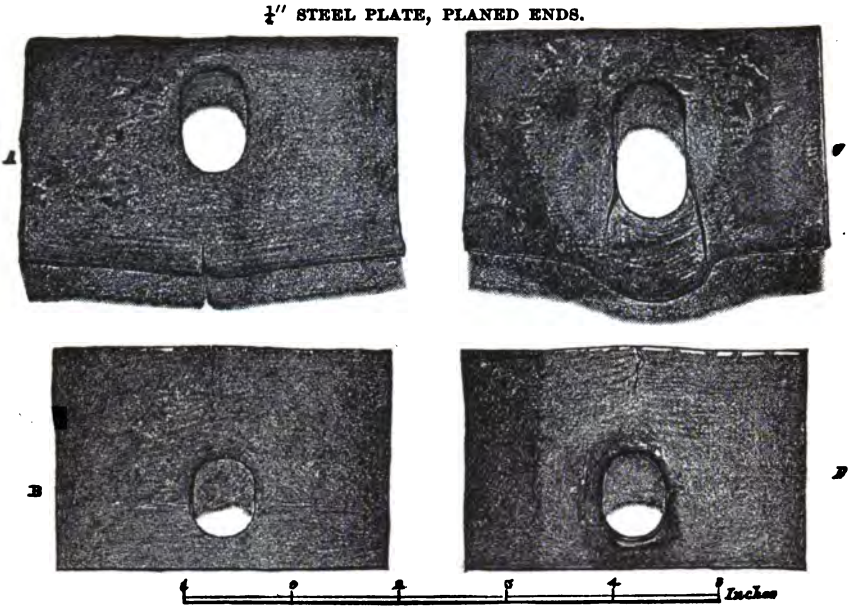
$\frac{1}{2}$″ STEEL PLATE, PLANED ENDS.



$\frac{1}{2}$″ IRON PLATE, PLANED ENDS.

Fractures in plates having $\frac{11}{16}$″ punched holes.
$1\frac{1}{4}$″ from center of hole to end of Plates *A* and *B*.
$1\frac{1}{2}$″ from center of hole to end of Plates *C* and *D*.

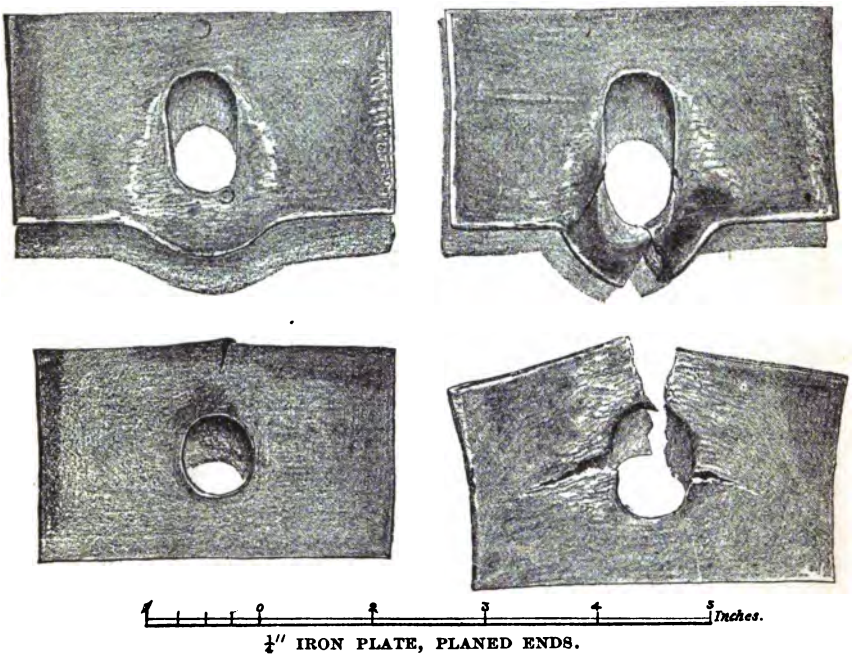
½″ STEEL PLATE, PLANED ENDS.



½″ IRON PLATE, PLANED ENDS.

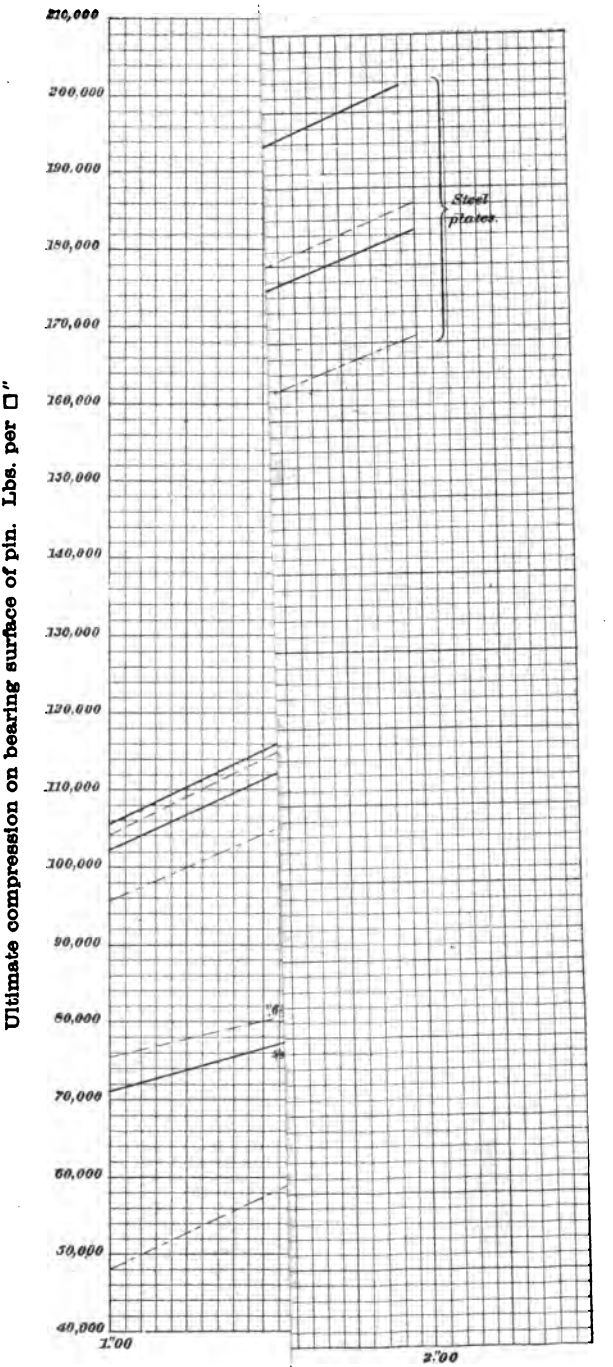
Fractures in plates having $1\frac{1}{16}$″ punched holes.
$1\frac{1}{2}$″ from center of hole to end of Plates *A* and *B*.
$1\frac{1}{4}$″ from center of hole to end of Plates *C* and *D*.

½′ STEEL PLATE, PLANED ENDS.



½″ IRON PLATE, PLANED ENDS.

Fractures in plates having $\frac{5}{8}$″ drilled holes.
1″ from center of hole to end of plate.

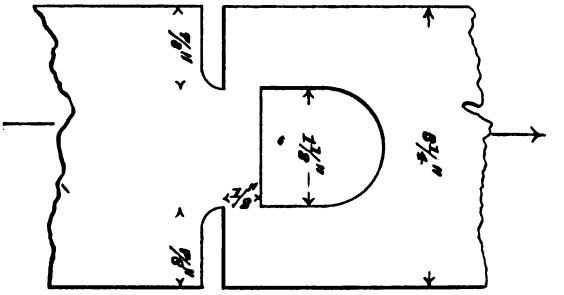

Ultimate compression on bearing surface of pin. Lbs. per □"
210,000
200,000
190,000
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
Steel plates.
1.00
2.00
Dist
Drill
Punc
Punc

¼″ Wrought-iron Plate.

(Shearing parallel to grain.)

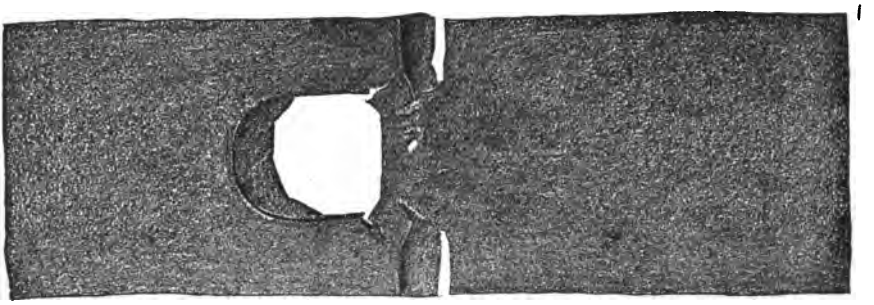
No. 300.

FORM OF SPECIMEN.



Shearing area, ″.5×″.276×2 = .276 square inch.
Ultimate strength, 7,728 pounds = 28,800 pounds per square inch.

SPECIMEN AFTER FRACTURE.

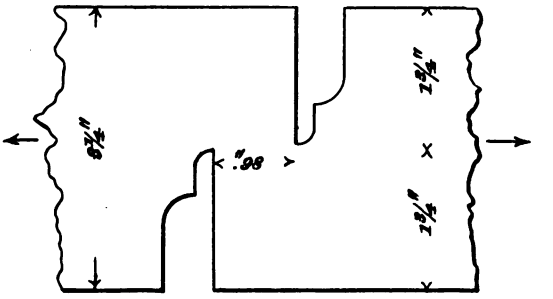


No. 301.

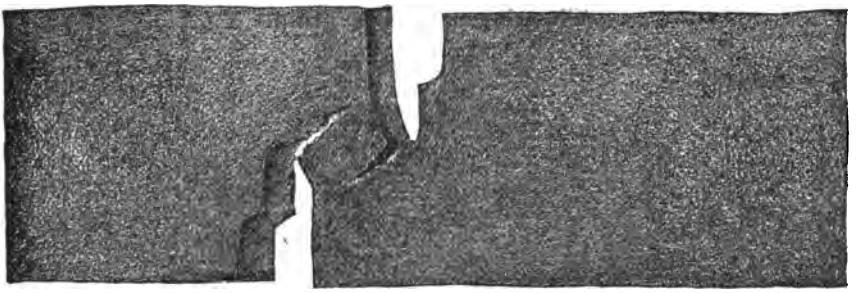
Same form as No. 300.
Shearing area, ″.50×″.278×2 = .278 square inch.
Ultimate strength, 7,850 pounds = 28,240 pounds per square inch.
Failed same manner as No. 300.

No. 302.

FORM OF SPECIMEN.



SPECIMEN AFTER FRACTURE.



Shearing area, ".98×".279 = .273 square inch.
Ultimate strength, 6,900 pounds = 25,270 pounds per square inch.

No. 303.

Same form as No. 302.
Shearing area, ".98×".276 = .270 square inch.
Ultimate strength, 6,980 pounds = 25,290 pounds per square inch.
Failed in the same manner as No. 302.

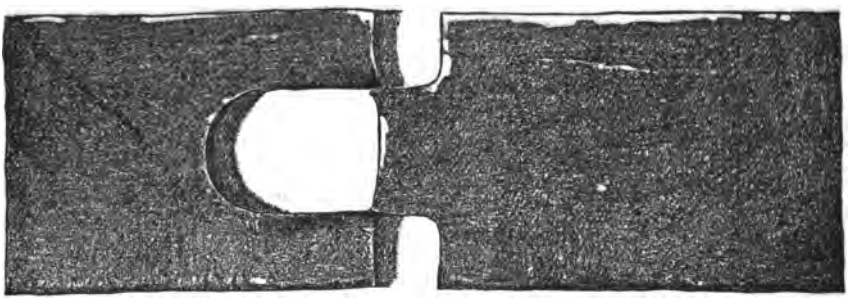
¼" STEEL PLATE.

(Shearing parallel to direction of rolling.)

No. 318.

Original form of specimen same as No. 300.

SPECIMEN AFTER FRACTURE.



Shearing area, ".50×".245× 2 = .245 square inch.
Ultimate strength, 9,450 pounds = 38,570 pounds per square inch.

No. 319.

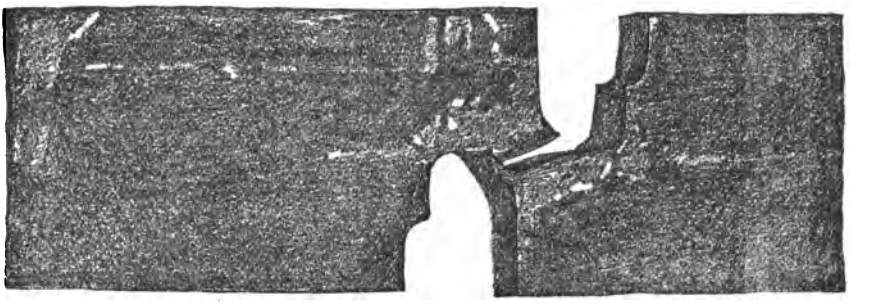
¼" steel, same form as No. 318.
Shearing area, ".50×".249×2 = .249 square inch.
Ultimate strength, 10,120 pounds = 40,640 pounds per square inch.
Tore out evenly at each shearing line.

No. 320.

¼″ STEEL PLATE.

Original form of specimen same as No. 302.

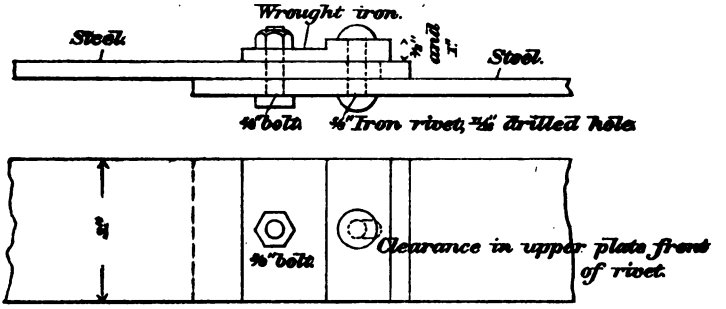
SPECIMEN AFTER FRACTURE.



Shearing area, 1″ × ″.255 = .255 square inch.
Ultimate strength, 9,200 pounds = 36,080 pounds per square inch.
Failed by shearing from bottom of groove to bottom of groove, one line of shearing.

DETAILS OF RIVETED JOINTS—FRICTION OF RIVETS.

Experiments to determine the force necessary to slip a joint or plates held together by the friction of the rivet only.



Gauge measures elongations in 10″ section, including the joint. The ⅝″ bolt used to hold washer in place while riveting removed before the test.

No. 463.

Thickness of steel plates, ″.31 each; width, about 3″.
Thickness of washer ″.50.
Length of rivet under heads, 1″.12.

Loads applied.	Elongation.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
2,000	.0003	
3,000	.0008	
4,000	.0013	
5,000	.0020	Slipping began at 5,400 pounds.
5,500	.0092	

No. 463.

Maximum resistance, 5,980 pounds a load, which was reached and held momentarily.

It seems quite probable that the available resistance offered by the friction of the rivet was 5,400 pounds.

The joint was found oily after shearing the rivet.

Rivet sheared between steel plates at about 14,000 pounds.

No. 464.

Thickness of steel plates, ″.30 each.
Thickness of washer, ″.50.
Total length of rivet under heads, 1″.10.
Shearing area of rivet, .371 square inch.

Loads applied.	Elongation.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
2,000	.0005	
3,000	.0008	
4,000	.0016	
5,000	.0019	
5,500	.0024	
5,950	.0098	Rapid slipping.
64,000	.....	Maximum load reached.
15,650	.....	Shearing strength of rivet=42,180 pounds per square inch.

Joint oily. Sheared the rivet between steel plates and started off rivet head slightly. Hole in lower steel plate elongated about ″.01.

No. 465.

Thickness of steel plates, ″.30, ″.28; thickness of washer, 1″.
Length of rivet under heads, 1″.58.

Loads applied.	Elongation.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
2,000	.0002	
3,000	.0007	
4,000	.0011	
4,800	.0012	
	.0034	Sudden slip. This load considered the limit of friction between the plates. Unaffected by cutting of the surface in contact.
5,000	.0052	
5,500	.0083	
6,000	.0100	
6,500	.0112	
7,000	.0128	
7,480	.0162	Rapid slipping takes place.
8,000	.0661	
8,500	.1112	
9,000	.1522	
10,000	.2032	
11,000	.2134	
12,000	.2282	
13,000	.2472	
15,900	.....	Ultimate strength of rivet=42,830 pounds per square inch.

The peculiar behavior of the above specimen thought to be due to a burr on the upper plate cutting the under plate, which would increase the resistance after first slipping took place.

No. 466.

Thickness of steel plate, ".30 each; thickness of washer, 1". Length of rivet, 1".60.

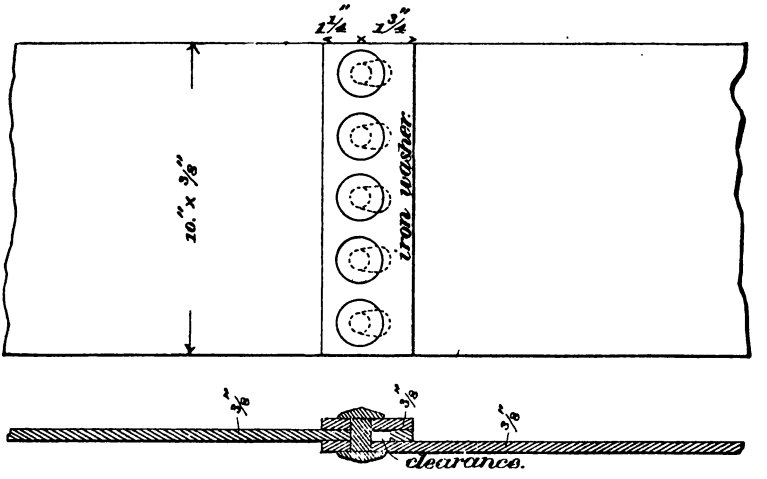
Loads applied.	Elongation.	Remarks.
Pounds.	*Inch.*	
1,000	0.	
2,000	.0002	
3,000	.0008	
4,000	.0016	
5,000	.0038	
5,500	.0058	This load considered sufficient to overcome the friction caused by the rivet when unaffected by the cutting of the surfaces in contact.
6,000	.0115	
7,000	.0310	
8,000	.0610	
8,500	.1690	
8,900	.....	Maximum resistance due to friction of rivet.
12,800	.....	Ultimate shearing strength of rivet = 87,180 pounds per square inch.

Plates cut same as in experiment No. 465.

Friction of rivets.

No. 248.

$\frac{3}{8}$" IRON PLATE.

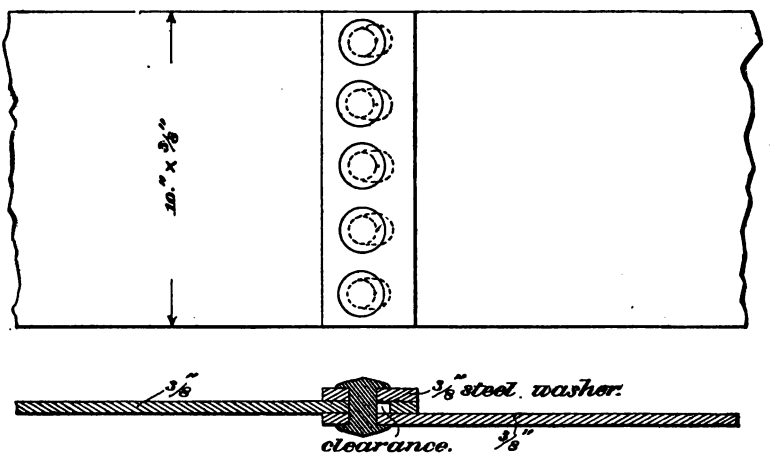


Five $\frac{11}{16}$" iron rivets.
Five $\frac{3}{4}$" drilled holes, with clearance front of rivets in upper plate.
This specimen made up of plates in test F . . clamped with 20" exposure between holder faces; corners of holes rounded about ".05.
Shearing area of five rivets ($\frac{3}{4}$" diameter), 2.21 square inches.

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0008	.....	
15,000	.0018	.....	
20,000	.0030	.....	
25,000	.0050	.....	
27,000	.0068	.....	
28,000	.0075	.....	
29,000	.0090	.....	
30,000	.0108	.....	
5,000	.....	.0058	
31,000	.0130	.....	Rapid slipping began when load passed 31,000 pounds. The resistance to slipping continued about 30,000 pounds, till total slip was ".15.
32,000	.15	.....	
35,000	.18	.....	Friction per rivet, $\frac{31000}{5}$ = 6,200 pounds.
40,000	.26	.....	
45,000	.32	.....	
50,000	.35	.....	
55,000	.36	.....	
60,000	.38	.....	
65,000	.40	.....	
70,000	.41	.....	
75,000	.45	.....	
80,000	.47	.....	Shearing strength of rivets, 41,630 pounds per square inch.
85,000	.54	.....	
90,000	.65	.....	
92,000	.....	.....	Ultimate strength. Sheared rivets.

Under plate cut vicinity of rivet holes by upper plate slipping over it.

$\frac{3}{8}$" STEEL PLATE.



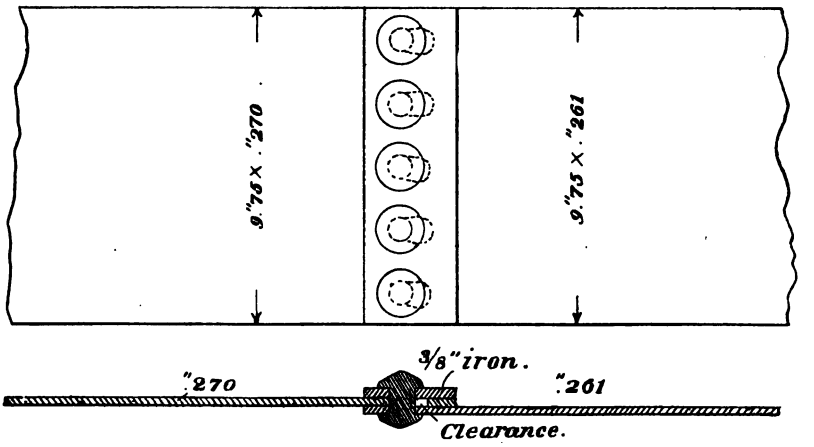
Five $\frac{11}{16}$" iron rivets; $\frac{3}{4}$" drilled holes.
Clearance given rivets in upper plates.
Corners of rivet holes rounded about ".05.
Shearing area five rivets ($\frac{3}{4}$" diameter), 2.21 square inches.

Loads applied.	Elongation in 10 inches.	Remarks.
Pounds.	*Inch.*	
5,000	0.	
10,000	.0010	
12,000	.0115	
14,000	.0020	
16,000	.0022	
18,000	.0028	
20,000	.0030	
22,000	.0035	
24,000	.0041	
26,000	.0048	
28,000	.0065	
30,000	.0100	
31,000	.0121	Slipping continued, the resistance falling to 28,000 pounds.
31,600	.180	
32,000	.125	
33,000	.19	Friction per rivet, $\frac{31600}{5}$ = 6,320 pounds.
34,000	.22	
35,000	.23	
40,000	.32	
45,000	.36	
50,000	.375	
55,000	.385	
60,000	.40	
65,000	.425	
70,000	.445	
75,000	.47	
80,000	.49	
85,000	.54	
88,000	.....	Ultimate strength. Sheared rivets.

Shearing strength of rivets = 39,820 pounds per square inch.

No. 250.

$\frac{1}{4}$" IRON PLATE.



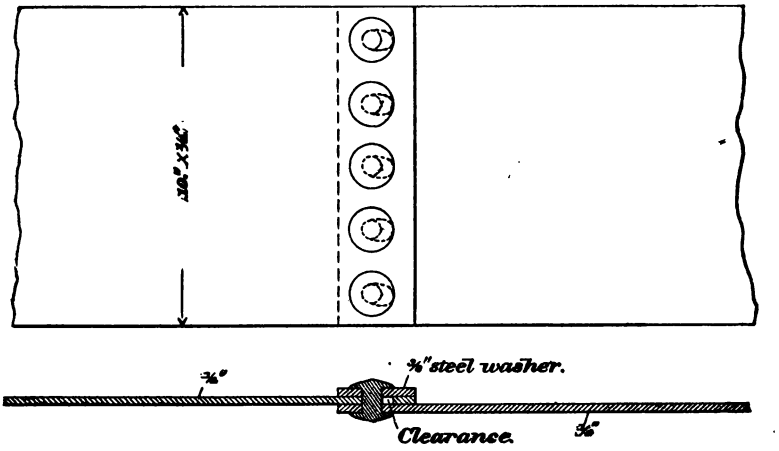
Five $\frac{5}{8}$" iron rivets; drilled holes ".69 diameter.
Corners of rivet holes rounded about ".05.
Shearing area of rivets (5 = ".69 diameter), 1.87 square inches.

Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.	.....	
10,000	.0015	.....	
12,000	.0020	.....	
14,000	.0025	.....	
16,000	.0032	.....	
18,000	.0040	.....	
20,000	.0050	.....	
21,000	.0058	.....	
22,000	.0065	.....	
23,000	.0070	.....	
24,000	.0080	.....	
25,000	.0092	.....	
5,000	.....	.0045	
26,000	.0110	.....	Friction per rivet, $\frac{26000}{5}$ = 5,200 pounds.
27,000	.1230	.....	
28,000	.1260	.....	
29,000	.1410	.....	
30,000	.1520	.....	
35,000	.220	.....	
40,000	.25	.....	
45,000	.29	.....	
50,000	.32	.....	
60,000	.37	.....	
70,900	.....	.....	Sheared rivets.

Shearing strength of rivets = 37,914 pounds per square inch.

No. 251.

$\frac{1}{4}$″ Steel Plate.



Five $\frac{5}{8}$″ iron rivets (Burden's); drilled holes, ″.69 diameter.
Rivet holes rounded about ″.05.
Shearing area of rivets, 1.87 square inches.

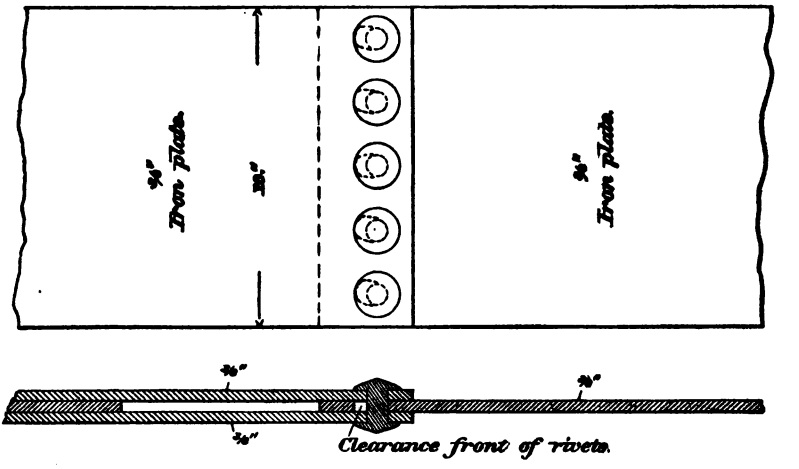
Loads applied.	Elongation in 10 inches.	Permanent set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
5,000	0.		
10,000	.0010		
12,000	.0018		
14,000	.0028		
16,000	.0038		
5,000		0.0008	
16,000	.0032		
18,000	.0040		
20,000	.0050		
5,000		.0020	
21,000	.0058		
22,000	.0062		
23,000	.0070		
24,000	.0078		
25,000	.0082		
26,000	.0090		$\frac{12}{32}\frac{29}{32}$ = 5,400 pounds sudden slip.
27,000	.0100		
28,000	.0128		
29,000	.0132		
30,000	.0162		Friction per rivet, $\frac{29}{32}\frac{28}{32}$ = 6,000 pounds.
31,000	.0640		
32,000	.0710		
33,000	.0935		
34,000	.0990		
35,000	.1660		
36,000	.172		
37,000	.182		
40,000	.260		
45,000	.295		
50,000	.325		
60,000	.380		
72,700			Sheared the rivets.

Shearing strength of rivets, 38,880 pounds per square inch.

No. 636.

$\frac{3}{8}$″ IRON PLATE.

FRICTION OF RIVETS.



Five $\frac{3}{4}$″ iron rivets; drilled holes, ″.81 diameter.

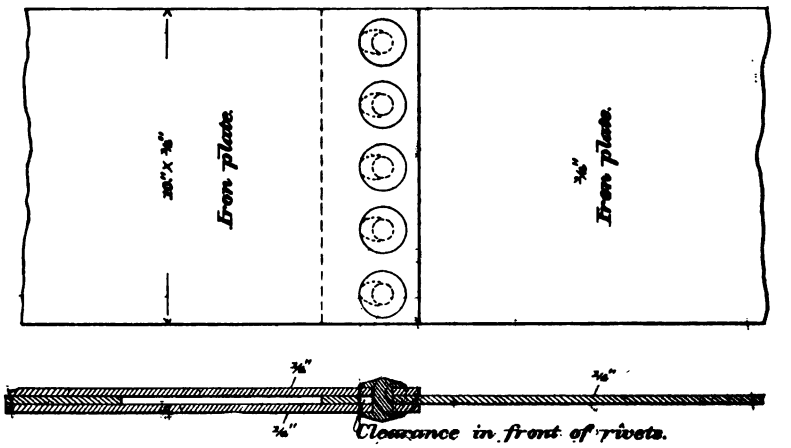
Loads applied.	Elongation in 10 inches.	Remarks.
Pounds.	*Inch.*	
5,000	0.	
10,000	0.	
15,000	.0005	
20,000	.0008	
25,000	.0010	
30,000	.0018	
33,000	.0020	
35,000	.0022	
38,000	.0028	
40,000	.0030	
42,000	.0032	
44,000	.0038	
46,000	.0040	
48,000	.0048	
50,000	.0069	
52,000	.3470	Sudden slip of plates.

10,400 pounds friction per rivet.

No. 637.

¼″ IRON PLATE.

FRICTION OF RIVETS.

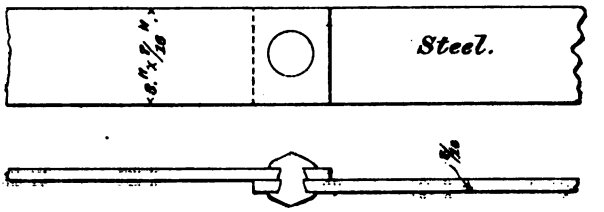


Five $\frac{11}{16}$″ iron rivets; drilled holes, $\frac{3}{4}$″ diameter.

Loads applied.	Elongation in 10 inches.	Remarks.
Pounds.	*Inch.*	
5,000	0.	
10,000	0.	
20,000	.0008	
30,000	.0020	
38,000	.0333	Rapid slipping of plates.

7,600 pounds friction per rivet.

SHEARING OF STEEL RIVETS.



No. 467.

FIRST RIVET.

$\frac{11}{16}$" steel rivet. (Kind of steel not known.)
Punched holes: Punch, ".753 diameter; die, ".774 diameter.
Shearing area of rivet, .45 square inch.
Ultimate shearing strength, 25,750 pounds = 57,220 pounds per square inch.

No. 468.

SECOND RIVET.

Ultimate shearing strength, 26,490 = 58,870 pounds per square inch.

ANALYSIS OF IRON, STEEL, ETC.

[Made by Capt. JOHN PITMAN, Ordnance Department.]

10" RODMAN GUNS, Nos. 362 AND 363.

	No. 362.	No. 363.	Difference.
	Per cent.	*Per cent.*	*Per cent.*
Silicon	1.765	1.750	0.015
Phosphorus	0.144	0.130	0.014
Sulphur	0.109	0.098	0.011
Manganese	0.500	0.433	0.067
Copper	0.034	0.026	0.002
Cobalt	0.016	0.008	0.008
Nickel	0.010	0.015	0.005
Combined carbon	0.559	0.697	0.138
Graphite	2.432	2.130	0.302
Total carbon	2.991	2.827	0.164

STEEL PLATES USED FOR EXPERIMENTS ON RIVETED JOINTS.

	$\frac{3}{8}$" steel.	$\frac{5}{8}$" steel.	$\frac{7}{8}$" steel.
	Per cent.	*Per cent.*	*Per cent.*
Carbon	0.115	0.126	0.130

STEEL BARS.

[Supposed to be alike.]

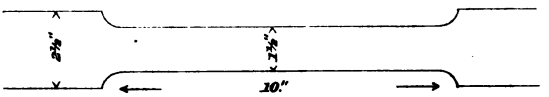
	Carbon.		Carbon.	Tensile strength per square inch.
				Pounds.
No. 1	0.173	Duplicate	0.187	60,445
No. 2	0.087	do	0.094	60,185
No. 3	0.553	do	0.565	74,896+
No. 4	0.180	do	0.188	63,230
No. 5	0.234	do	0.210	62,640
No. 6	0.128	do	0.129	59,730
No. 7	0.174	do	0.183	66,069
No. 8	0.198	do	0.208	59,545
No. 9	0.172			59,760

BRONZE, ETC.

	Copper.	Nickel and cobalt.	Zinc.	Tin.	Iron.	Antimony.	Arsenic.	Lead.	Bismuth.	Silver.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Hub from cavalry forge wheel	86.35	.....	3.56	9.94	0.040	.....	.....	0.130	0.010	.....
Alloy from Rock Island	0.175	0.157	0.020	0.438	0.150	5.905	0.041	93.000	0.052	Trace.
Brazing Wood bridge gun	58.85	.....	.....	.....	.....	.....	.....	.....	.....	.....
Trunnion Wood bridge gun	3.53	.....	.....	.....	92.64	.....	.....	.....	.....	.....
Crab obelisk	91.08	.....	.....	8.33	0.09	.....	.....	.....	.....	.....

Tensile test of wrought iron used in spliced specimens Nos. 607, 608, 609, and 610.

FORM OF TENSILE SPECIMENS.

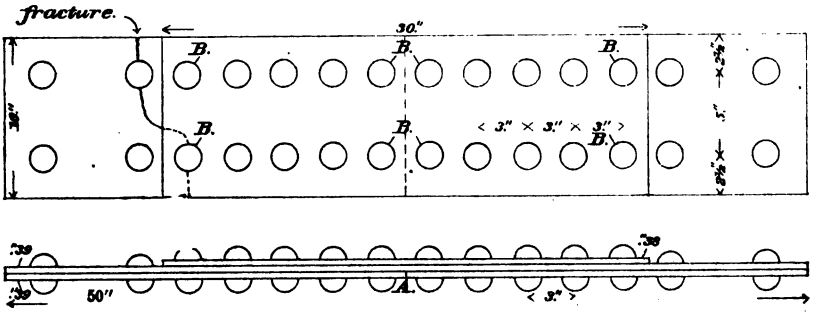


Number of test.	Mark on specimen.	Size of specimen.		Sectional area.	Elastic limit.		Ultimate strength.	
		Thickness.	Width.		Actual pounds.	Pounds per square inch.	Actual pounds.	Pounds per square inch.
		Inch.	*Inch.*	*Square inch.*				
605	C	.388	1.510	.5820	20,200	34,708	28,500	48,970
606	R	.373	1.503	.5606	18,050	32,200	24,100	42,990

Number of test.	Elongation in 10 inches.	Uniform elongation.	Area at fracture.	Contraction of area.	Appearance of fracture.
	Per cent.	*Per cent.*	*Square inch.*	*Per cent.*	
605	10.5	9	.34 × 1.47 = .4998	14.1	Fibrous lamellar.
606	6.9	6	.34 × 1.44 = .4896	12.7	Do.

No. 607.

Tensile test of $\frac{3}{8}$″ × 10″ wrought-iron spliced plates.



$\frac{13}{16}$″ iron rivets, "Burden's best."
$\frac{7}{8}$″ drilled holes.

No. 607.

Gross sectional area of two spliced plates ″.78 × 10″ = 7.8 square inches.
Net sectional area of two spliced plates, ″.78 × 8″.25 = 6.44 square inches.

Under load of 80,000 pounds, joint *A* of under spliced plate opened perceptibly.

While sustaining 150,000 pounds a straight edge 24″ long was placed on the welt and deflection of ″.13 at middle found, plates being concave on the side of the welt at 170,000 pounds tension. Joint *A* had opened from ″.03 to ″.04. At this load scale had started on rivet-heads *B* on sides towards middle of specimen. A load of 210,000 pounds was applied and then reduced to zero load, leaving a permanent deflection of ″.20 at middle, as measured from a 24″ straight edge.

Ultimate strength of plates, 258,500 pounds, fracturing specimen at end rivet in welt on one side and at first rivet beyond welt on the other side of the plates.

Fracture fibrous lamellar.

Maximum strain on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plates	33,141
Tensile strain on net section of plates	40,140

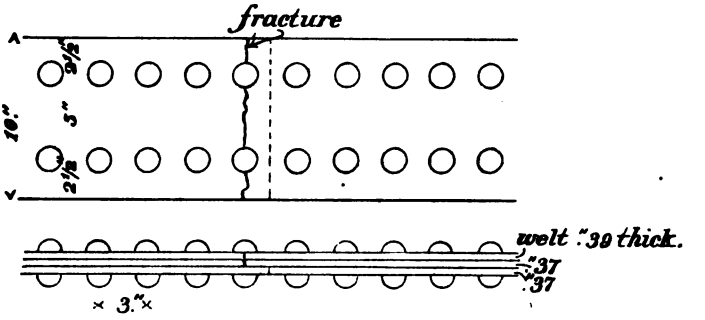
No. 608.

Duplicate of No. 607.

Gross sectional area of spliced plates, ″.76 × 10″ = 7.6 square inches.
Net sectional area of spliced plates, ″.76 × 8″.25 = 6.27 square inches.

Loads applied.	Remarks.
Pounds.	
50,000	Deflection at middle, ″.03, measured from 24″ straight edge.
100,000	Deflection at middle, ″.07, measured from 24″ straight edge.
150,000	Deflection at middle, ″.11, measured from 24″ straight edge.
200,000	Deflection at middle, ″.17, measured from 24″ straight edge.
0	Deflection at middle, ″.11, measured from 24″ straight edge.
250,600	Deflection at middle, ″.27, measured from 24″ straight edge.
279,100	Ultimate strength.

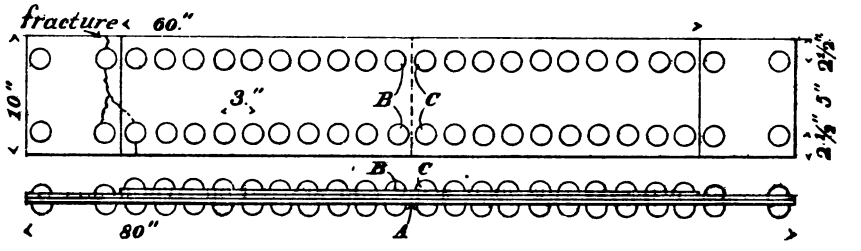
Fractured the continuous plate and the welt at the middle of the specimen at the first rivets from joint.



Maximum loads on joint.

	Pounds per sq. inch.
Tensile strain on gross section of plates	36,724
Tensile strain on net section of plates	44,514

No. 609.



Nominal thickness of plates, $\frac{3}{8}$".
$\frac{13}{16}$" iron rivets, "Burden's best"; $\frac{7}{8}$" drilled holes.
Gross sectional area of spliced plates, ".73×10" = 7.3 square inches.
Net sectional area of spliced plates, ".73×8".25 = 6.02 square inches.

Loads applied.	Remarks.
Pounds.	
50,000	Deflection at middle, ".02, measured from 24" straight edge.
100,000	Deflection at middle, ".04, measured from 24" straight edge.
150,000	Deflection at middle, ".06, measured from 24" straight edge.
200,000	Deflection at middle, ".07, measured from 24" straight edge.
240,000	Deflection at middle, ".06, measured from 24" straight edge.
254,800	Ultimate strength.

Fractured plate in the same manner as No. 607; failed.

Plates began to tear at rivet holes after the joint *A* was open ".20, the result of the distortion of the joint and the stretch of the welt and continuous plate for the section between rivets *B* and *C*.

Maximum loads on joint.

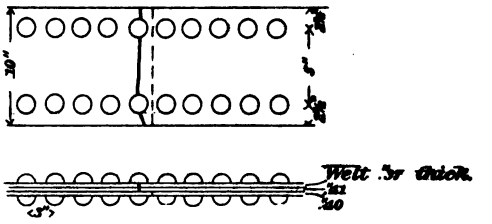
	Pounds per sq. inch.
Tensile strain on gross section of plates	34,900
Tensile strain on net section of plates	42,325

No. 610.

Duplicate of No. 609.
Gross sectional area of spliced plates, $''.81 \times 10'' = 8.1$ square inches.
Net sectional area of spliced plates, $''.81 \times 8''.25 = 6.68$ square inches.

Loads applied.	Remarks.
Pounds.	
50,000	Deflection at middle, ".02, measured from 24" straight edge.
100,000	Deflection at middle, ".04, measured from 24" straight edge.
150,000	Deflection at middle, ".05, measured from 24" straight edge.
200,000	Deflection at middle, ".08, measured from 24" straight edge.
240,000	Deflection at middle, ".10, measured from 24" straight edge.
273,200	Ultimate strength.

Fractured continuous plate and welt at middle of specimen at first rivets from joint.



Maximum loads on joint.

	Pounds per sq. inch
Tensile strain on gross section of plates	33,728
Tensile strain on net section of plates	40,898

Tensile tests of old boiler joints.

$\frac{3}{8}''$ WROUGHT IRON PLATE.

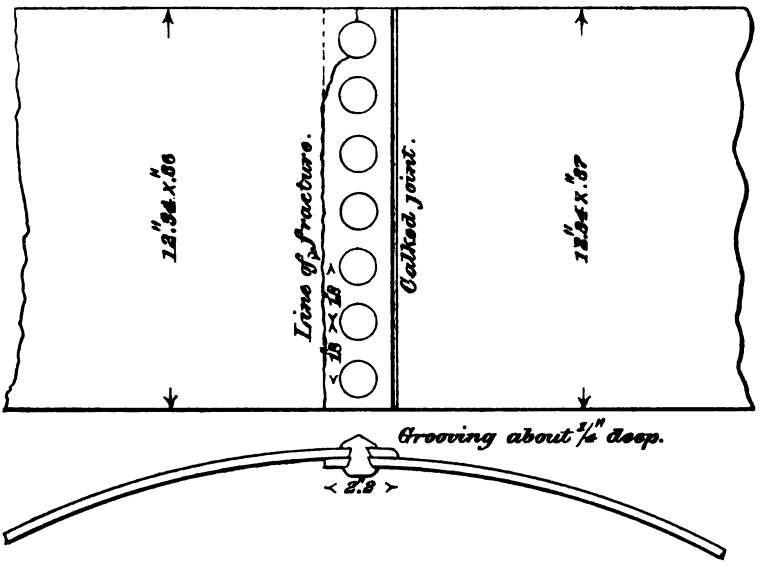
Specimens taken from the cylindrical part of a locomotive boiler which had been in service twenty-four years.
Diameter of shell, 52".
Steam pressure carried, 130 pounds per square inch.
Tensile test-piece No. 80 cut out crosswise the grain.
Joints Nos. 89, 90, and 91 tested lengthwise the grain of the iron.

No. 80.

Sectional area, $1''.500 \times ''.385 = .577$ square inch.
Elastic limit, 13,600 pounds = 23,570 pounds per square inch.
Ultimate strength, 26,200 pounds = 45,410 pounds per square inch.
Elongation, $1''.34$ in $10'' = 13.4$ per cent.
Uniform elongation, 10 per cent.
Area at fracture, $1''.37 \times ''.32 = .438$ square inch.
Contraction of area, 24.1 per cent.
Appearance of fracture fibrous, with marked lamination.

No. 89.

OLD BOILER PLATE JOINT, $\frac{3}{8}$" WROUGHT IRON.



$\frac{5}{8}$" Iron rivets. Hand driven. Punched holes.

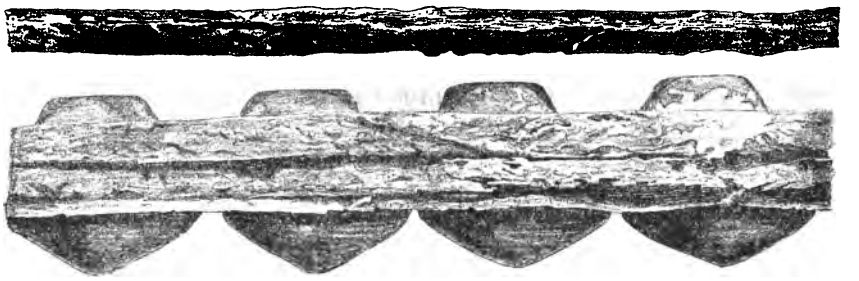
The curve of the joint (conforming to the curvature of the shell of the boiler, 52" diameter) was not straightened before placing in the testing machine. At 10,000 pounds tension the plate had straightened so as to open the crack where grooving had taken place. This crack did not appear before placing the specimen in the machine, as it followed the edge of the overlapping plate in part, and for part of its course was covered by the overlapping plate. As strains were increased this crack gradually opened. At 59,700 pounds tension snapping sounds were heard, which were heard frequently till the ultimate strength was determined.

Ultimate strength, 84,300 pounds.

Fracture occurred along the line where grooving had taken place, a distance of 10", then turning in its course slightly and tearing through the end rivet hole. Appearance of fracture dull, fibrous, and fine granular. The minimum thickness of metal at bottom of grooving was about ".06. The average thickness about ".09 for 10" length.

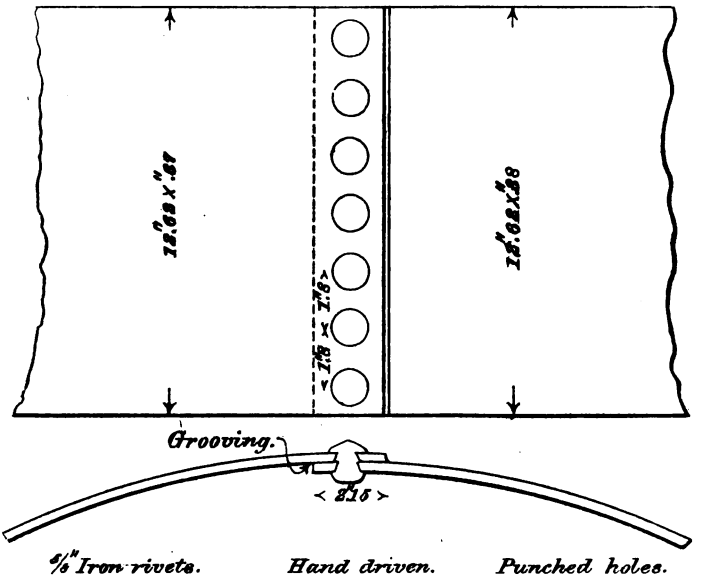
The area of fractured plate probably about 1.6 square inches.

The pull exerted by the machine tending to straighten the joint may have caused a more unfavorable effect on the plate and caused earlier ailure than would have been the case when the plate was in the boiler, he plate fracturing under the combined tensile and bending strains.



No. 90.

OLD BOILER PLATE JOINT, $\frac{3}{8}$" WROUGHT IRON.



Snapping sound heard at 56,000 pounds tension.

Ultimate strength, 83,500 pounds. Sheared rivets.

This joint was cleaned and carefully examined before the test was made to detect evidence of grooving, if any had taken place.

The inspection did not reveal any cracks from grooving. When, however, a tensile strain of 50,000 pounds had been reached, the grooving cracks appeared.

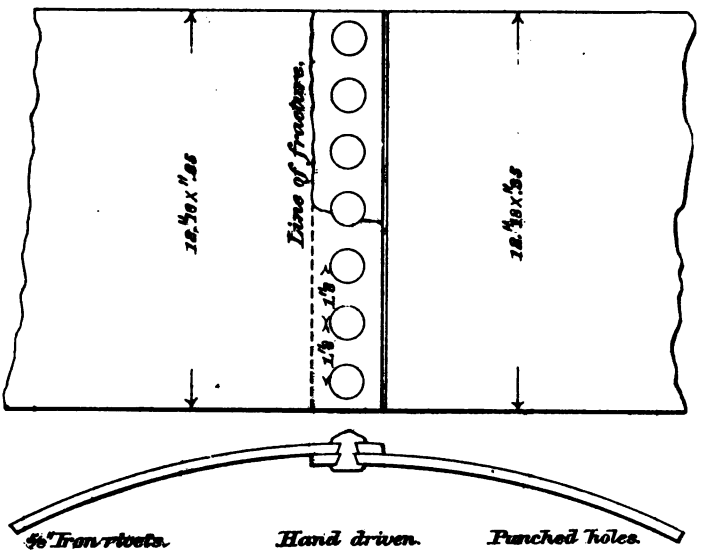
After having sheared the rivets in the first test of this joint, the grooved plate was placed in the testing machine and strains applied so as to fracture the plate through the grooving. This was accomplished by a tensile strain of 206,500 pounds.

The grooving had extended to an average depth of ".07. The appearance of the fractured metal was fibrous, with very marked lamination.

The head of a rivet was fractured, showing a granular appearance.

No. 91.

OLD BOILER PLATE.



Before placing this joint in the testing machine it was cleaned and carefully inspected, and by means of a scratch-awl grooving was detected in three places, having an aggregate length of $4\frac{3}{4}''$. An opinion at this time could not be formed as to the depth of the grooving. The cracks could not be followed with the point of the awl beyond the distance of $4\frac{3}{4}''$.

When a tensile strain was applied and the joint began to straighten, the grooving opened a length of 12″. Ultimate strength of joint, 84,200 pounds. Sheared five rivets and tore the plate along the line of grooving 6″, and through a rivet hole to the end of the lap. Maximum depth of grooving, ″.28.

From the fact that more than half the length of the grooving could not be seen before the test was made, it would appear very probable that cases of grooving exist that are wholly covered by the overlapping plate, and its presence even after a careful examination of the boiler is unsuspected.

The plate fractured with a fibrous appearance, slightly granular.

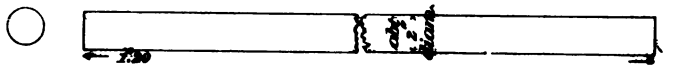
Appearance of fractured plate, Joint No. 91.

Tensile tests of single and double refined wrought iron.

ROUND BARS.

(Single refined bars from the Passaic Rolling Mill Company, Paterson, N. J.)

[FORM OF SPECIMENS.]



No. 593.

Mark on bar, S. 18.
Diameter, 2″.01.
Sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.		
15,850	5,000	.0127		
31,700	10,000	.0275		
	1,000		0.	
47,550	15,000	.0425		
63,400	20,000	.0572		
	1,000		0.	
65,000		.0600		
66,000		.0608		
67,000		.0618		
68,000		.0628		
69,000		.0637		
70,000		.0650		
71,000		.0659		
72,000		.0669		
73,000		.0679		
74,000		.0690		
75,000		.0699		
76,000		.0710		
77,000		.0721		
78,000	24,600	.0733		Elastic limit.
79,000		.0748		
80,000		.0780		
81,000		.0797		
82,000		.0815		
83,000		.0829		
84,000		.0850		
85,000		.0874		
86,000		.0925		
87,000		.0945		
88,000		.0968		
90,000		.1015		
92,000		.650		Sustained load 5 minutes.
95,100	30,000	.90		
110,950	35,000	2.12		
126,800	40,000	3.82		Elongation of 10″ sections: ″.81, ″.86, ″.89, ″.88, ″.88, ″.89, ″.89, ″.87.
142,650	45,000	6.84		
154,400		12.00		
0	0			Rested 5 minutes.
157,500	49,680	15.20		Ultimate strength.
0	0	15.58		= 19.5 per cent.

Elongation of 10″ sections: 1″.67 (2″.45 at fracture), 1″.92, 1″.90, 1″.89, 1″.96, 1″.95, 1″.90.
Diameter at fracture, 1″.66; area, 2.16 square inches.
Contraction of area, 32 per cent.
Fracture fibrous, slightly granular.

No. 594.

Mark on bar, S 19.
Diameter, 2″.01.
Sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.	.....	
15,850	5,000	.0120	.....	
31,700	10,000	.0260	.....	
.....	1,000	.....	0.	
47,550	15,000	.0406	.....	
63,400	20,000	.0545	.....	
.....	1,000	.....	—.0006	
65,000	.....	.0555	.....	
66,000	.....	.0563	.....	
67,000	.....	.0572	.....	
68,000	.....	.0581	.....	
69,000	.....	.0590	.....	
70,000	.....	.0600	.....	
71,000	.....	.0610	.....	
72,000	.....	.0620	.....	
73,000	.....	.0630	.....	
74,000	.....	.0640	.....	
75,000	.....	.0650	.....	
76,000	.....	.0661	.....	
77,000	.....	.0671	.....	
78,000	.....	.0681	.....	
79,000	.....	.0694	.....	
80,000	.....	.0705	.....	
81,000	.....	.0716	.....	
82,000	25,870	.0729	.....	Elastic limit.
83,000	.....	.0745	.....	
84,000	.....	.0758	.....	
85,000	.....	.0777	.....	
86,000	.....	.0796	.....	
87,000	.....	.0813	.....	
88,000	.....	.0835	.....	
89,000	.....	.0867	.....	
90,000	.....	.185	.....	Sustained load 5 minutes; stretching still going on.
95,100	30,000	1.00	.....	
110,950	35,000	2.29	.....	
126,800	40,000	4.06	.....	Elongation of 10″ sections: ″.88, ″.89, ″.90, ″.90, ″.88, ″.89, ″.89, ″.85.
142,650	45,000	7.00	.....	
156,400	49,338	.....	.....	Ultimate strength.
0	0	14.66	.....	=18.3 per cent.

Elongation of 10″ sections: 1″.65, 1″.72, 1″.70, 1″.69, 1″.81, 1″.90 (2″.50 at fracture), 1″.70.
Diameter at fracture, 1″.58; area, 1.96 square inches.
Contraction of area, 38 per cent.
Fracture, fibrous.

No. 595.

Mark on bar, S 20.
Diameter, 2″.01; sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.	.....	
15,850	5,000	.0120	.....	
31,700	10,000	.0270	.....	
.....	1,000	.....	—.0005	
47,550	15,000	.0424	.....	
63,400	20,000	.0577	.....	
.....	1,000	.....	.0014	
65,000	.....	.0597	.....	
66,000	.....	.0605	.....	
67,000	.....	.0618	.....	
68,000	.....	.0629	.....	
69,000	.....	.0639	.....	
70,000	.....	.0650	.....	
71,000	.....	.0660	.....	
72,000	.....	.0670	.....	
73,000	.....	.0681	.....	
74,000	.....	.0696	.....	
75,000	.....	.0708	.....	
76,000	.....	.0724	.....	
77,000	.....	.0735	.....	
78,000	.....	.0748	.....	
79,000	24,920	.0760	.....	Elastic limit.
80,000	.....	.0775	.....	
81,000	.....	.0788	.....	
82,000	.....	.0805	.....	
83,000	.....	.0820	.....	
84,000	.....	.0834	.....	
85,000	.....	.0850	.....	
86,000	.....	.0868	.....	
87,000	.....	.0889	.....	
88,000	.....	.0938	.....	
89,000	.....	.205	.....	Yielding continues.
95,100	30,000	1.00	.....	
110,950	35,000	2.25	.....	
126,800	40,000	4.10	.....	Elongation of 10″ sections:
142,650	45,000	7.30	.....	″.87, ″.93, ″.92, ″.93, ″.92, ″.91, ″.91, ″.90.
154,900	48,864	.....	.....	Ultimate strength.
0	0	14.69	.....	=18.4 per cent.

Elongation of 10″ sections: 1″.62 (2″.34 at fracture), 1″.75, 1″.82, 1″.81, 1″.81, 1″.75, 1″.79.
Diameter at fracture, 1″.59; area, 1.99 square inches.
Contraction of area, 37 per cent.
Appearance of fracture fibrous, with some cinder at center.

DOUBLE-REFINED WROUGHT IRON.

No. 526.

Mark on bar, S 218.
Diameter, 2″.01; sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.		
15,850	5,000	.0119		
31,700	10,000	.0268		
	1,000		−.0009	
47,550	15,000	.0415		
63,400	20,000	.0559		
	1,000		−.0018	
65,000		.0570		
66,000		.0580		
67,000		.0590		
68,000		.0600		
69,000		.0610		
70,000		.0620		
71,000		.0630		
72,000		.0640		
73,000		.0650		
74,000		.0660		
75,000		.0670		
76,000		.0680		
77,000		.0690		
78,000	24,610	.0703		Elastic limit.
79,000		.0716		
80,000		.0729		
81,000		.0740		
82,000		.0751		
83,000		.0762		
84,000		.0777		
85,000		.0789		
86,000		.0805		
87,000		.0820		
88,000		.0833		
89,000		.0850		
90,000		.0865		
91,000		.0882		
92,000		.0902		
93,000		.0956		
94,000		.1650		
95,100	30,000	.47		
110,950	35,000	2.10		
126,800	40,000	3.75		Elongation of 10″ sections:
142,650	45,000	6.55		″.81, ″.81, ″.83, ″.84, ″.82, ″.85, ″.80, ″.81.
158,600				
0	0			Rested 5 minutes.
160,500	50,631			Ultimate strength.
0	0	16.35		=20.4 per cent.

Elongation of 10″ sections: 1″.90, 1″.95, 2″.19, 2″.08, 2″.01, 2″.09, 1″.97, 2″.13.

Diameter at fracture, 1″.54; area, 1.86 square inches.

Contraction of area, 41 per cent.

Fracture fibrous; broke outside 80″ section, 2″ from face of holder jaws.

No. 597.

Mark on bar, S 219.
Diameter, 2″.01; sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.		
15,850	5,000	.0124		
31,700	10,000	.0270		
	1,000		0.	
47,550	15,000	.0423		
63,400	20,000	.0566		
	1,000		0.	
65,000		.0580		
66,000		.0591		
67,000		.0600		
68,000		.0610		
69,000		.0620		
70,000		.0630		
71,000		.0640		
72,000		.0649		
73,000		.0660		
74,000		.0668		
75,000		.0675		
76,000		.0685		
77,000		.0695		
78,000		.0704		
79,250	25,000	.0718		
	1,000		.0005	
80,000		.0728		
81,000		.0740		
82,000		.0750		
83,000		.0762		
84,000		.0774		
85,000		.0785		
86,000		.0798		
87,000		.0811		
88,000		.0824		
89,000		.0840		
90,000		.0852		
91,000		.0868		
92,000		.0885		
93,000		.0902		
94,000		.0918		
95,000		.0935		
96,000		.0968		
97,000		.315*		
98,000		.97		Sustained load 5 minutes.
110,950	35,000	1.90		
126,800	40,000	3.50		Elongation of 10″ sections: ″.76, ″.76, ″.78, ″.78, ″.79, ″80, ″.79, ″.78.
142,650	45,000	6.16		
160,500				
0	0			Rested 3 minutes.
161,400	50,915			Ultimate strength.
0	0	20.37		=25.5 per cent.

*About.

Elongation of 10″ sections: 2″.19, 2″.26, 2″.49, 2″.40 (2″.95 at fracture), 2″.90, 2″.44, 2″.72.
Diameter at fracture, 1″.50; area, 1.77 square inches.
Contraction of area, 44 per cent.
Fracture fibrous, cup-shaped.

No. 598.

Mark on bar, S 220.
Diameter, 2″.01; sectional area, 3.17 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,170	1,000	0.		
15,850	5,000	.0120		
31,700	10,000	.0270		
	1,000		.0003	
47,550	15,000	.0421		
64,400	20,000	.0570		
	1,000		.0015	
65,000		.0588		
66,000		.0600		
67,000		.0610		
68,000		.0619		
69,000		.0629		
70,000		.0640		
71,000		.0650		
72,000		.0660		
73,000		.0670		
74,000		.0680		
75,000		.0690		
76,000		.0701		
77,000		.0714		
78,000		.0725		
79,250	25,000	.0738		
	1,000		.0047	
80,000		.0750		
81,000		.0762		
82,000		.0775		
83,000		.0790		
84,000		.0803		
85,000		.0820		
86,000		.0831		
87,000		.0848		
88,000		.0869		
89,000		.0890		
90,000		.0910		
91,000		.0948		
92,000		.134		
93,000		.400		
95,100	30,000	.90*		
110,950	35,000	2.10*		
126,800	40,000	3.80*		
142,650	45,000	6.65*		Elongation in 10″ sections: ″.81, ″.82, ″.86, ″.84, ″.85, ″.86, ″.83, ″.82.
158,000				
0	0			Rested 3 minutes.
159,150	50,205			Ultimate strength.
146,000				At time of fracture.
0	0	19.00		=23.7 per cent.

*About.

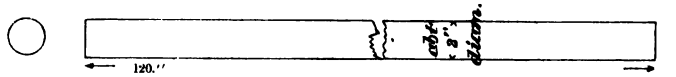
Elongation of 10″ sections: 2″.10, 2″.06, 2″.21, 2″.38, 2″.39 (3″.35 at fracture), 2″.30, 2″.13.
Diameter at fracture, 1″.50; area, 1.77 square inches.
Contraction of area, 44 per cent.
Fracture fibrous, cup-shaped.

Tensile tests of single and double refined.

WROUGHT IRON, ROUND BARS.

[From the Elmira Iron and Steel Rolling Mill Company.]

FORM OF SPECIMEN.



SINGLE REFINED BARS.

No. 599.

Mark on bar, L 8.
Diameter, 2".03; sectional area, 3.24 square inches.
Gauged length, 80".

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,240	1,000	0.		
16,200	5,000	.0125		
32,400	10,000	.0270		
	1,000		0.	
48,600	15,000	.0422		
64,800	20,000	.0565		
	1,000		—.0009	
66,000		.0575		
67,000		.0585		
68,000		.0594		
69,000		.0604		
70,000		.0611		
71,000		.0621		
72,000		.0631		
73,000		.0640		
74,000		.0650		
75,000		.0660		
76,000		.0670		
77,000		.0680		
78,000		.0690		
79,000		.0700		
80,000		.0711		
81,000	25,000	.0721		
	1,000		—.0002	
82,000		.0739		
83,000		.0750		
84,000		.0762		
85,000		.0775		
86,000		.0787		
87,000		.0801		
88,000		.0815		
89,000		.0831		
90,000		.0843		
91,000		.0859		
92,000		.0874		
93,000		.0890		
94,000		.0909		
95,000		.0936		
96,000		.0970		
97,000		.1053		
98,000		.206		
100,440	31,000	.70		
113,400	35,000	1.50		
129,600	40,000	2.96		Elongation of 10" sections: ".70, ".70, ".69, ".69, ".69, ".68, ".68, ".66.
145,800	45,000	5.35		
166,600				Rested 3 minutes.
0	0			Ultimate strength.
167,400	51,667			= 22 per cent.
0	0	17.6		

Elongation of 10" sections: 2".38, 2".30, 2".19 (2".85 at fracture), 2".15, 1".96, 1".96, 1".77.
Diameter at fracture, 1".63; area, 2.09 square inches.
Contraction of area, 36 per cent.
Appearance of fracture: Fibrous, 70 per cent.; granular, 30 per cent.

No. 600.

Mark on bar, L 9.
Diameter, 2″.02; sectional area, 3.20 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,200	1,000	0.		
16,000	5,000	.0118		
32,000	10,000	.0265		
	1,000		0.	
48,000	15,000	.0420		
64,000	20,000	.0572		
	1,000		−.0002	
66,000		.0590		
68,000		.0610		
70,000		.0630		
72,000		.0650		
74,000		.0670		
75,000		.0682		
76,000		.0693		
77,000		.0703		
78,000		.0715		
79,000		.0727		
80,000	25,000	.0740		
	1,000		.0624	
81,000		.0751		
82,000		.0765		
83,000		.0780		
84,000		.0790		
85,000		.0801		
86,000		.0815		
87,000		.0829		
88,000		.0843		
89,000		.0857		
90,000		.0873		
91,000		.0890		
92,000		.0910		
93,000		.0928		
94,000		.0950		
95,000		.0970		
96,000		.0995		
97,000		.1034		
98,000		.465		
102,200		.85		
112,000	35,000	1.45		
128,000	40,000	3.00		Elongations of 10″ sections:
144,000	45,000	5.35		″.66, ″.67, ″.68, ″.68, ″.70, ″.66, ″.65, ″.67.
162,700	50,844			Ultimate strength.
0	0	13.0		= 16.3 per cent.

Elongations of 10″ sections: 1″.55, 1″.60 (1″.82 at fracture), 1″.68, 1″.60, 1″.56, 1″.55, 1″.54.
Diameter at fracture, 1″.78; area, 2.51 square inches.
Contraction of area, 22 per cent.
Appearance of fracture: Fibrous, 15 per cent.; granular, 85 per cent.

No. 601.

Mark on bar, L 10.
Diameter, 2″.02; sectional area, 3.20 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,200	1,000	0.		
16,000	5,000	.0125		
32,000	10,000	.0270		
	1,000		.0005	
48,000	15,000	.0421		
64,000	20,000	.0569		
	1,000		.0005	
66,000		.0586		
68,000		.0606		
70,000		.0621		
72,000		.0644		
74,000		.0660		
75,000		.0669		
76,000		.0680		
77,000		.0689		
78,000		.0700		
79,000		.0709		
80,000	25,000	.0719		
	1,000		.0007	
81,000		.0730		
82,000		.0736		
83,000		.0746		
84,000		.0757		
85,000		.0767		
86,000		.0780		
87,000		.0790		
88,000		.0800		
89,000		.0811		
90,000		.0824		
91,000		.0837		
92,000		.0854		
93,000		.0865		
94,000		.0881		
95,000		.0900		
96,000		.0916		
97,000		.0931		
98,000		.0950		
99,000		.0971		
100,000		.122		
112,000	35,000	1.20		
128,000	40,000	2.47		
144,000	45,000	4.55		Elongations of 10″ sections: ″.55, ″.56, ″.56, ″.59, ″.58, ″.59, ″.59, ″.59.
169,500				
0	0			Rested 3 minutes.
169,800	53,062			Ultimate strength at time of fracture.
152,000				
0	0	16.80		= 21 per cent.

Elongation of 10″ sections: 1″.73, 1″.89, 1″.90, 2″.12, 2″.15, 2″.58, 2″.30, 2″.10.
Diameter at fracture, 1″.56; area, 1.91 square inches.
Contraction of area, 40 per cent.
Appearance of fracture: Fibrous, 95 per cent.; granular, 5 per cent.
Broke outside 80″ section, 6″ from face of holder jaws.

DOUBLE REFINED WROUGHT IRON BARS.

No. 602.

Mark on bar, L 208.
Diameter, 2″.02; sectional area, 3.20 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,200	1,000	0.		
16,000	5,000	.0120		
32,000	10,000	.0271		
	1,000		.0020	
48,000	15,000	.0421		
64,000	20,000	.0571		
	1,000		.0020	
66,000		.0590		
68,000		.0610		
70,000		.0629		
72,000		.0650		
74,000		.0670		
75,000		.0680		
76,000		.0690		
77,000		.0700		
78,000		.0710		
79,000		.0720		
80,000	25,000	.0730		
	1,000		.0039	
81,000		.0745		
82,000		.0756		
83,000		.0768		
84,000		.0780		
85,000		.0790		
86,000		.0801		
87,000		.0815		
88,000		.0829		
89,000		.0844		
90,000		.0858		
91,000		.0871		
92,000		.0887		
93,000		.0905		
94,000		.0921		
95,000		.59		
112,000	35,000	1.78		
128,000	40,000	3.37		Elongation of 10″ sections: ″.75, ″.76, ″.77, ″.76, ″.79, ″.79, ″.79, ″.79.
144,000	45,000	6.10		
160,000				
0	0			Rested 2½ minutes.
160,500	50,156			Ultimate strength.
0	0	18.16		= 22.7 per cent.

Elongation of 10″ sections: 1″.70, 1″.88, 1″.94, 2″.14, 2″.19, 2″.40, 3″.02, 2″.84.
Diameter at fracture, 1″.53; area, 1.84 square inches.
Contraction of area, 43 per cent.
Appearance of fracture fibrous, cup-shaped.
Broke ¾″ outside gauged length, 12″ from face of holder jaws.

No. 603.

Mark on bar, L 209.
Diameter, 2″.02; sectional area, 3.20 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,200	1,000	0.		
16,000	5,000	.0125		
32,000	10,000	.0270		
	1,000		.0018	
48,000	15,000	.0416		
64,000	20,000	.0559		
	1,000		.0019	
66,000		.0575		
68,000		.0594		
70,000		.0610		
72,000		.0628		
74,000		.0646		
76,000		.0661		
78,000		.0679		
80,000	25,000	.0696		
	1,000		.0004	
81,000		.0700		
82,000		.0712		
83,000		.0721		
84,000		.0731		
85,000		.0740		
86,000		.0750		
87,000		.0760		
88,000		.0770		
89,000		.0781		
90,000		.0792		
91,000		.0809		
92,000		.0820		
93,000		.0834		
94,000		.0856		
95,000		.0876		
96,000		.55		
99,200	31,000	.80		
112,000	35,000	1.80		
128,000	40,000	3.50		Elongation of 10″ sections: ″.80, ″.81, ″.81, ″.81, ″.80, ″.80, ″.79, ″.77.
144,000	45,000	6.33		
159,400				
0	0			Rested 3 minutes.
159,800	49,937			Ultimate strength at time of fracture.
143,000				
0	0	18.05		=22.6 per cent.

Elongation of 10″ sections: 2″.31, 2″.59 (3″.60 at fracture), 2″.31, 2″.02, 1″.83, 1″.71, 1″.65.
Diameter at fracture, 1″.50; area, 177 square inches.
Contraction of area, 45 per cent.
Fracture fibrous, cup-shaped.

No. 604.

Mark on bar, L 210.
Diameter, 2″.02; sectional area, 3.20 square inches.
Gauged length, 80″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,200	1,000	0.		
16,000	5,000	.0120		
32,000	10,000	.0265		
	1,000		—.0004	
48,000	15,000	.0410		

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
64,000	20,000	.0552		
	1,000		—.0020	
66,000		.0570		
68,000		.0590		
70,000		.0610		
72,000		.0630		
74,000		.0650		
76,000		.0668		
78,000		.0690		
80,000	25,000	.0710		
	1,000		—.0010	
81,000		.0723		
82,000		.0735		
83,000		.0748		
84,000		.0763		
85,000		.0776		
86,000		.0790		
87,000		.0803		
88,000		.0819		
89,000		.0835		
90,000		.0854		
91,000		.0870		
92,000		.0896		
93,000		.0920		
94,000		.0945		
95,000		.0960		
96,000		.765		
99,200	31,000	.86		
112,000	35,000	1.70		
128,000	40,000	3.35		Elongation of 10″ sections: ″.78, ″.76, ″.76, ″.76, ″.75, ″.75, ″.77, ″.79.
144,000	45,000	6.07		
160,400				
0	0			
160,600	50,188			Ultimate strength.
0	0	15.96		=19.9 per cent.

Elongation of 10″ sections: 1″.81, 1″.93, 1″.96, 1″.87, 1″.87, 1″.91, 2″.04, 2″.50.

Diameter at fracture, 1″.52; area, 1.82 square inches.

Contraction of area, 43 per cent.

Fracture fibrous, cup-shaped; broke 2″ outside of gauged section and 10″ from face of holder jaws.

Tensile tests of single and double refined wrought iron (round bars).

[Tabulated results.]

Number of test.	Mark on bar.	Kind of iron.	Diameter of specimen.	Sectional area	Elastic limit.	Ultimate strength.	Elongation in 80 inches.	Contraction of area.	Appearance of fracture.
			Inch.	*Sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*	
593	S 18...	Single refined	2.01	3.17	24,600	49,680	19.5	32	Fibrous; slightly granular.
594	S 19...	....do	2.01	3.17	25,870	49,338	18.3	38	Fibrous.
595	S 20...	....do	2.01	3.17	24,920	48,864	18.4	37	Fibrous, with some cinder at center.
596	S 218 ..	Double refined	2.01	3.17	24,610	50,631	20.4	41	Fibrous.
597	S 219...	....do	2.01	3.17		50,915	25.5	44	Fibrous; cup-shaped.
598	S 220...	....do	2.01	3.17		50,205	23.7	44	Do.
599	L 8 ...	Single refined	2.03	3.24		51,667	22	36	Fibrous, 70 per cent.; granular, 30 per cent.
600	L 9 ...	....do	2.02	3.20		50,844	16.3	22	Fibrous, 15 per cent.; granular, 85 per cent.
601	L 10 ..	....do	2.02	3.20		53,062	21	40	Fibrous, 95 per cent.; granular, 5 per cent.
602	L 208..	Double refined	2.02	3.20		50,156	22.7	43	Fibrous; cup-shaped.
603	L 209..	....do	2.02	3.20		49,937	22.6	45	Do.
604	L 210 ..	....do	2.02	3.20		50,188	19.9	43	Do.

No. 362.

WROUGHT IRON, SINGLE ROLLED BAR.

Supplementary test of No. 973.

Mark on bar, L 5.

Bar tested a second time after about eight months' rest.

Original sectional area of bar, $5''.05 \times 1.''28 = 6.46$ square inches.

Rapid stretching began at 365,000 pounds = 56,500 pounds per square inch. Ultimate strength, 381,000 pounds = 58,980 pounds per square inch on original section.

Area of fracture, $4''.70 \times 1''.14 = 5.36$ square inches.

Contraction of area (from original size), 17 per cent.

Fracture: Granular, 70 per cent.; fibrous, 30 per cent.

10″ sections after second fracture, elongations of B: 2″.10, 1″.85, 1″.80, 1″.80, 1″.86, 1″.82 A.

Second fracture occurred 16″ from the first fracture.

Bar heated slightly hotter than cherry-red, and allowed to cool in the open air. About 12″ to 15″ of the ends were not heated.

Average sectional area of bar, $4''.75 \times 1''.17 = 5.56$ square inches.

Gauged length, 50″.

Loads applied.	Pounds per square inch on reduced section.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
5,560	1,000	0.		
27,800	5,000	.0080		
55,600	10,000	.0188		
	1,000		.0008	
83,400	15,000	.0292		
111,200	20,000	.0401		
	1,000		.0030	
115,000		.0421		
120,000		.0448		
125,000		.0470		
130,000		.0498		
135,000		.0525		
140,000	26,080	.0560		Elastic limit.
145,000		.0780		
150,000		.1770		
234,000	42,090			Ultimate strength.
	21,670			Elastic limit on original section.
	36,220			Ultimate strength on original section.

Broke 17½″ from end A. Fracture, fibrous, 100 per cent.

This fracture took place near the end of the annealed section of the bar.

Stretch of bar about 33 per cent. from original length.

Bar tested again, breaking with 269,000 pounds = 48,380 pounds per square inch = 41,640 pounds per square inch on original section. Fracture, fibrous, 100 per cent.

Supplementary tests of single and double rolled wrought-iron bars.

No. 384.

Mark on bar, L 2.

Bar retested after ten months' rest.

Present sectional area (average section), $2''.84 \times ''.94 = 2.67$ square inches.

Gauged length, 50″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,670	1,000	0.		
13,350	5,000	.0178		
26,700	10,000	.0175		
	5,000		.0005	
40,050	15,000	.0275		
53,400	20,000	.0365		
	1,000		.0008	
66,750	25,000	.0460		
80,100	30,000	.0558		
	1,000		.0010	
85,000		.0590		
90,000		.0628		
95,000		.0660		
100,000		.0695		
106,800	40,000	.0742		
	1,000		.0011	
110,000		.0768		
115,000		.0800		
116,000		.0808		
117,000		.0816		
118,000		.0825		
119,000		.0830		
120,000		.0838		
121,000		.0846		
122,000		.0852		
123,000		.0858		
124,000		.0866		
125,000		.0875		
126,000		.0880		
127,000		.0888		
128,000		.0895		
129,000		.0905		
130,000		.0910		
131,000		.0918		
132,000		.0922		
133,000		.0930		
134,000		.0938		
135,000		.0946		
136,000		.0955		
137,000		.0960		
138,000		.0968		
139,000		.0975		
140,000		.0984		
141,000		.0990		
142,000		.1000		
143,000		.1008		
144,000		.1015		
145,000		.1022		
146,000		.1030		
147,000		.1038		
148,000		.1048		
149,000		.1055		
150,000		.1062		
151,000		.1072		
152,000		.1080		
153,000		.1090		
154,000		.1100		
155,000		.1108		
156,000		.1118		
157,000		.1128		
158,000		.1138		
159,000		.1148		
160,000		.1158		
161,000		.1168		
162,000		.1178		
163,000		.1188		
164,000		.1200		

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
165,000	61,800	.1210		Elastic limit on original area, 53,920 pounds per square inch.
166,000		.1225		
167,000		.1238		
168,000		.1250		
169,000		.1262		
170,000		.1278		
171,000		.1290		
172,000		.1308		
173,000		.1322		
174,000		.1340		
175,000		.1358		
176,000		.1378		
177,000		.1400		
178,000		.1428		
179,000		.1455		
180,000		.1490		Ultimate strength on original area 63,130 pounds per square inch.
193,200	72,360			
0	0	3.40		= 6.8 per cent.

Elongation of 10″ sections from original lengths: 2″.41, 2″.72, 2″.70 ☼, 2″.47, 2″.30, 2″.20, 2″.01.

Area at fracture, 2″.72 × ″.88 = 2.39 square inches.
Contraction of area from original section, 21.9 per cent.
Granular fracture.

No. 385.

The longer fractured end of bar No. 384 was now taken and heated over an open fire till dull red in daylight, and then cooled in open air.
Present sectional area, 2″.80 × ″.92 = 2.58 square inches.
Gauged length, 20″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,580	1,000	0.		
12,900	5,000	.0028		
25,800	10,000	.0062		
38,700	15,000	.0100		
51,600	20,000	.0140		
	1,000		.0008	
55,000		.0150		
58,000		.0160		
61,000		.0170		
64,000		.0185		
67,000		.0191		
70,000	27,130	.0200		Elastic limit, 22,880 pounds per square inch on original section.
73,000		.0221		
76,000		.0358		
79,000		{.0595 / .0688}		After sustaining load 3 minutes.
82,000		.0750		
85,000		.147		
126,200	48,910			Ultimate strength, 41,240 pounds per square inch on original section.
0	0	1.52		=7.6 per cent.

Elongation of original 10″ sections: 3″.60, 3″.08 ☼, 2″.91.

Area at fracture, 2″.52 × ″.80 = 2.02 square inches.
Contraction of area (from original section), 34 per cent.
Fracture, dull fibrous.

No. 386.

Supplementary test of bar L 201.

Rested since original test ten months.
Present sectional area (average, 2″.87 × ″.95 = 2″.73 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,730	1,000	0.		
13,650	5,000	.0080		
27,300	10,000	.0180		
54,600	20,000	.0370		
81,900	30,000	.0560		
109.200	40,000	.0748		
	1,000		.0006	
122,850	45,000	.0840		
136,500	50,000	.0940		
	1,000		.0011	
138,000		.0955		
140,000		.0968		
142,000		.0982		
144,000		.0999		
146,000		.1013		
148,000		.1030		
150,000		.1046		
151,000		.1058		
152,000		.1064		
153,000		.1072		
154,000		.1081		
155,000		.1090		
156,000		.1100		
157,000		.1110		
158,000		.1120		
159,000		.1128		
160,000		.1138		
161,000		.1150		
162,000		.1160		
163,000		.1170		
164,000		.1180		
165,000	60,440	.1192		Elastic limit, 53,920 pounds per square inch on original section.
166,000		.1206		
167,000		.1218		
168,000		.1230		
169,000		.1245		
170,000		.1258		
171,000		.1272		
172,000		.1288		
173,000		.1305		
174,000		.1320		
175,000		.1340		
176,000		.1360		
178,000		.1408		
180,000		.1480		
182,000		.155		
184,000		.535		
193,000	70,696			Ultimate strength, 63,070 pounds per square inch on original area.
0	0	2.13		= 4.3 per cent.

Elongation of 10″ sections from original lengths: 8″.28 ✱, 1″.99, 1″.93, 1″.98, 1″.95, 2″.

Area at fracture, 2″.76 × ″.89 = 2.46 square inches.

Contraction of area (from original area), 19.6 per cent.

Fracture: Granular, 90 per cent.; with fibrous spot, 10 per cent.

The longer fractured end of bar No. 386 was now taken and heated over an open fire till it would melt solder rubbed on its surface; temperature called 370°, allowed to cool in the open air.

No. 387.

L 201, continued.

Present sectional area, 2″.83 × ″.92 = 2.6 square inches.

Gauged length, 20″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,600	1,000	0.		
13,000	5,000	.0030		
26,000	10,000	.0068		
2,600	1,000	0.		
13,000	5,000	.0030		
26,000	10,000	.0068		
39,000	15,000	.0108		
52,000	20,000	.0145		
	1,000		0.	
55,000		.0155		
58,000		.0162		
61,000		.0171		
64,000		.0180		
67,000		.0190		
70,000		.0200		
73,000		.0208		
76,000		.0215		
79,000		.0225		
82,000		.0235		
85,000		.0241		
88,000		.0250		
91,000		.0260		
94,000		.0270		
97,000		.0280		
100,000		.0288		
103,000		.0295		
106,000		.0305		
109,000		.0312		
112,000		.0320		
115,000		.0330		
118,000		.0339		
121,000		.0348		
124,000		.0356		
127,000		.0365		
130,000		.0370		
133,000		.0380		
136,000		.0388		
139,000		.0398		
142,000		.0408		
145,000		.0415		
148,000		.0422		
151,000		.0432		
154,000		.0442		
157,000		.0452		
160,000		.0462		
163,000		.0470		
166,000		.0480		
169,000		.0490		
176,000	67,700			Ultimate strength, 57,520 pounds per square inch on original section.
0	0	0		

Area at fracture, 2″.56 × ″.78 = 2 square inches.

Contraction of area (from original section), 34.6 per cent.

Fracture fibrous, 60 per cent.; interspersed with granular spots, 40 per cent.

Broke outside 20″, gauged length.

During this test the bar stretched in the vicinity of the fracture and slightly at the opposite end, about ″.07 in ″.10.

Tested again March 1, 1882.

Ultimate strength, 191,000 pounds = 62,420 pounds per square inch on original section.

Fracture: Fibrous, 60 per cent.; granular, 40 per cent.

Supplementary test of bar L 203.

Rested nine months since original test.
Present sectional area, 2″.84 × ″.94 = 2″.67 square inches.
Gauged length, .50″.

No. 388.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,670	1,000	0.		
13,350	5,000	.0075		
26,700	10,000	.0170		
53,400	20,000	.0355		
80,100	30,000	.0540		
106,800	40,000	.0725		
133,500	50,000	.0910		
	1,000		.0006	
140,000		.0960		
150,000		.1032		
152,000		.1050		
154,000		.1068		
156,000		.1085		
158,000		.1102		
160,000		.1120		
161,000		.1128		
162,000		.1138		
163,000		.1148		
164,000		.1159		
165,000		.1170		
166,000		.1180		
167,000		.1190		
168,000		.1200		
169,000		.1210		
170,000		.1220		
171,000	64,040	.1232		Elastic limit, 55,880 pounds per square inch on original section.
172,000		.1248		
173,000		.1262		
174,000		.1278		
175,000		.1288		
176,000		.1300		
177,000		.1320		
178,000		.1338		
179,000		.1352		
180,000		.1375		
181,000		.1395		
182,000		.1420		
183,000		.1446		
184,000		.1478		
185,000		.1512		
186,000		.1582		
187,000		.1660		
193,900	72,620			Ultimate strength, 63,360 pounds per square inch on original section.
0	0	2.10		= 4.2 per cent.

Elongation of original 10″ sections: 2″.12, 2″.30 , 2″.11, 2″.06, 1″.98, 2″:06.
Area at fracture, 2″.75 × ″.89 = 2.45 square inches.
Contraction of area from original section, 19.9 per cent.
Fracture: Granular, 70 per cent.; fibrous, 30 per cent.

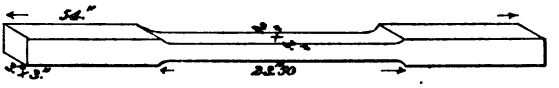
Tabulation of tensile tests of wrought-iron bars, showing original strength and strength after the bars had rested, also strength after annealing.

Number of test.	Condition of bar when tested.	Size of bar when tested.			Strains on original section.		Strains on reduced section.		Uniform elongation from original length.	Contraction of area from original section.	Appearance of fracture.	Remarks.
		Width.	Thick.	Sectional area.	Elastic limit.	Ultimate strength.	Elastic limit.	Ultimate strength.				
		Inch.	*Inch.*	*Sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Pr. ct.*	*Pr. ct.*		
993	Original	3.05	1	3.05	29,500	51,150	.....	.....	21	31.5	Fine fibrous	
	Rested four months since original test.	.....	.....	.....	.....	60,000	.....	.....	24	.....	Fibrous, 90 per cent.; granular 10 per cent.	
994	Original	3.05	1	3.05	28,500	51,110	.....	.....	21	36.1	Fine fibrous	
	Rested four and two-thirds months	.....	.....	.....	53,440	61,960	.....	.....	25	33.8	Fibrous, 92 per cent.; granular, 8 per cent.	
981	Original	3.05	1.01	3.08	28,000	50,390	.....	.....	14	35.1	Fibrous	
	Rested five months	.....	.....	.....	.....	60,390	.....	.....	20	21.8	Granular, 70 per cent.; fibrous, 30 per cent.	
973	Original	5.05	1.28	6.46	27,500	50,500	.....	.....	13	24.2	Fibrous, 95 per cent.; granular, 5 per cent.	
	Rested eight months	.....	.....	.....	56,500	58,980	.....	.....	18	17	Fibrous, 30 per cent.; granular, 70 per cent.	
	Heated cherry-red and cooled in open air.	4.75	1.17	5.56	21,670	{36,220 / 41,640}	26,080	{42,090 / 48,380}	33	.....	Fibrous	Broke at end of annealed section.
774	Original	3.03	1.01	3.06	29,500	53,630	.....	.....	16	36	Fibrous, 92 per cent.; granular, 8 per cent	
384	Rested ten months	2.84	.94	2.67	53,920	63,130	61,800	72,360	23	21.9	Granular	
385	Heated dull red and cooled in open air.	2.80	.92	2.58	22,800	41,240	27,130	48,910	32	34	Dull fibrous	
777	Original	3.03	1.01	3.06	29,000	53,560	.....	.....	15	37.9	Fibrous	
386	Rested ten months	2.87	.95	2.73	53,920	63,070	60,440	70,696	19	19.6	Fibrous, 10 per cent.; granular, 90 per cent	
387	Heated to 370° and cooled in open air.	2.83	.92	.....	57,520	57,520	67,700	67,700	19	34.6	Fibrous, 60 per cent.; granular, 40 per cent	
	Rested fifteen days after third test	.....	.....	.....	.....	62,420	.....	.....	.....	.....	....do	
971	Original	3.03	1.01	3.06	32,500	53,500	.....	.....	16	27.5	Fibrous	
388	Rested nine months	2.84	.94	2.67	55,880	63,360	64,040	72,620	21	19.9	Fibrous, 30 per cent.; granular, 70 per cent.	
389	Rested nine months	2.84	.92	2.61	.....	66,010	.....	77,400	21	19.9	Fine granular	

Tensile test of wrought iron for 3″×3″ compression tests.

No. 321.

FORM OF SPECIMEN.



Gauged length, 20″.
Sectional area, 6 square inches.

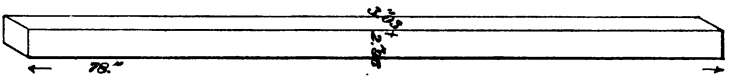
Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
6,000	1,000	0.		
30,000	5,000	.0030		
60,000	10,000	.0070		
	1,000		0.	
90,000	15,000	.0108		
108,000	18,000	.0130		
120,000	20,000	.0150		
	1,000		.0009	
125,000		.0160		
130,000		.0170		
132,000		.0176		
134,000		.0181		
136,000		.0185		
138,000		.0189		
140,000		.0192		
142,000		.0199		
144,000		.0205		
146 000	24,330	.0210		Elastic limit.
148,000		.0219		
150,000	25,000	.0228		
	1,000		.0050	
152,000		.0260		
154,000		.0280		
156,000		.0420		Still elongates under this load.
308,400	51,600			Ultimate strength.
0	0	4.31		= 21.5 per cent.

Elongation of 1″ sections: ″.22, ″.21, ″.20, ″.23, ″.26, ″.36, ″.46 ✠, ″.28, ″.22, ″.19, ″.18, ″.18, ″.18, ″.17, ″.18, ″.17, ″.17, ″.17, ″.17, 17″, ″.17.

Area at fracture, 2″.47 × 1″.67=4.12 square inches.
Contraction of area, 31.3 per cent.
Appearance of fracture: Fibrous, 60 per cent.; granular, 40 per cent.
Light-colored fracture.

No. 322.

Tensile test of wrought iron for 3″×3″ compression tests.



Sectional area, 8.97 square inches.
Gauged length, 20″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
8,970	1,000	0.		
44,850	5,000	.0030		
89,700	10,000	.0071		
	1,000		.0002	
134,550	15,000	.0121		
161,460	18,000	.0155		
179,400	20,000	.0178		
	1,000		.0032	
180,000		.0182		Rested 10 minutes.
182,000		.0188		
184,000		.0188		
186,000		.0190		
188,000		.0191		
190,000		.0192		
192,000		.0195		
194,000		.0198		
196,000		.0200		
198,000		.0205		
200,000		.0208		
202,000		.0212		
204,000		.0219		
206,000		.0222		
208,000		.0226		
210,000		.0228		
212,000		.0231		
214,000		.0235		
216,000		.0240		
218,000		.0248		
220,000		.0251		
222,000		.0259		
224,250	25,000	.0268		
	1,000		.0086	
226,000		.0280		
228,000		.0290		
230,000	25,640	.0300		Elastic limit.
232,000		.0325		
234,000		.0490		
236,000		.0860		
452,500	50,446			Ultimate strength.
0	0	4.30		= 21.5 per cent.

Elongation of 1″ sections: ″.20, ″.20, ″.21, ″.22, ″.22, ″.22, ″.22, ″.22, ″.21, ″.22, ″.22, ″.22, ″.22, ″.23, ″.23, ″.24, ″.24, ″.23, ″.23, ″.24.

Area at fracture, 2″.56 × 2″.50 = 6.4 square inches.

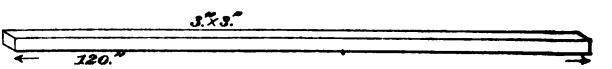
Contraction of area, 28.6 per cent.

Broke 4″ from face of holder jaws.

Appearance: Fibrous, 40 per cent.; granular, 60 per cent.

No. 323.

Tensile test of wrought iron for 3″ × 3″ compression tests.



Sectional area, 9 square inches.

Gauged length, 50″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
9,000	1,000	0.		
45,000	5,000	.0078		
90,000	10,000	.0172		
	1,000		.0002	
135,000	15,000	.0270		
162,000	18,000	.0335		
180,000	20,000	.0400		

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
	1,000		.0062	
185,000		.0459		
190,000		.0505		
192,000		.0540		
194,000		.0555		
196,000		.0570		
198,000		.0598		
200,000		.0650		
202,000		.0712		
204,000		.0870		
206,000		.128		
	1,000			Rested one hour.
446,000				Ultimate strength.
0	0	11.36		= 22.7 per cent.

Elongation of 5″ sections: 1″.11, 1″.20, 1″.30, 1″.20, 1″.19, 1″.21, 1″.11, 1″.04, 1″.02, 1″.02.

Area at fracture, 2″.45×2″.45 = 6 square inches.

Contraction of area, 33.3 per cent.

Broke at face of holder jaws.

Appearance: Fibrous, 45 per cent.; granular, 55 per cent.

No. 390.

Tensile test of 3″×3″ wrought iron, bar branded.

STIRLING BEST—BEST REFINED.

Total length of bar, about 78″.

Ganged length, 24″.

Sectional area, 3″.02×3″.02 = 9.12 square inches.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
9,120	1,000	0.		
45,600	5,000	.0030		
91,200	10,000	.0075		
	1,000		0.	
136,800	15,000	.0120		
182,400	20,000	.0161		
	1,000		.0005	
188,000		.0170		
193,000		.0178		
198,000		.0182		
203,000		.0190		
208,000		.0195		
213,000		.0200		
218,000		.0210		
223,000		.0215		
228,000	25,000	.0225		
	1,000		.0020	
230,000		.0231		
232,000		.0238		
234,000		.0241		
236,000		.0245		
238,000		.0251		
240,000		.0260		
242,000		.0262		
244,000		.0266		
246,000	26,970	.0270		Elastic limit.
248,000		.0278		
250,000		.0286		
252,000		.0440		
254,000		.1100		
260,000		.136		
270,000		.192		
449,000	49,230			Ultimate strength.
0	0	3.15		=18.1 per cent.

Elongation of inch sections after fracture of bar: ″.15, ″.14, ″.14, ″.14, ″.13, ″.13, ″.13, ″.13, ″.13, ″.13, ″.13, ″.14, ″.15, ″.13, ″.13, ″.13, ″.13, ″.12, ″.13, ″.13, ″.13, ″.13, ″.13, ″.13, ″.14, ″.13.

Fractured about 1 inch inside the section covered by holder jaws.

Area at fracture, 2″.83×2″.78=7.87 square inch.

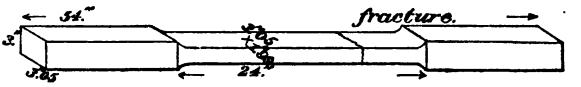
Contraction of area, 13.7 per cent.

Appearance of fracture: Granular, 95 per cent.; fibrous, 5 per cent.

No. 395.

Tensile test of 3″×3″ wrought-iron bar.

FORM OF SPECIMEN.



Sectional area, 3″.05×1″.99=6.07 square inches.

Gauged length, 24″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
6,070	1,000	0.		
30,350	5,000	.0031		
60,700	10,000	.0078		
	1,000		.0002	
91,050	15,000	.0128		
121,400	20,000	.0185		
	1,000		.0020	
124,000		.0192		
127,000		.0200		
130,000		.0210		
133,000		.0220		
136,000		.0230		
139,000	22,900	.0240		Elastic limit.
142,000		.0258		
145,000		.0282		
148,000		.0310		
151,750	25,000	.0400		
	1,000		.0200	
154,000		.0490		
157,000		.0560		
160,000		.0720		
163,000		.098		
296,000	48,764			Ultimate strength.
0	0	4.85		=20.2 per cent.

Elongation of 1″ sections after fracture: ″.16, ″.20, ″.22, ″.21, ″.29 ✸, ″.21, ″.23, ″.21, ″.20, ″.20, ″.20, ″.20, ″.22, ″.22, ″.26, ″.23, ″.23, ″.22, ″.20, ″.21, ″.20, ″.18, ″.18, ″.15.

Area of fracture, 2″.78×1″.83=5.09 square inches.

Contraction of area, 16.1 per cent.

Broke 6″ from neck, with granular fracture varying in degree of coarseness, fibrous about 5 per cent.

Seams in iron.

No. 396.

Off same bar as No. 395.

Tested full size as it came from the rolls.

Total length, 126″.75.

Gauged length, 80″.

Sectional area, 3″.03×3″.02=9.15 square inches.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
9,150	1,000	0.		
45,750	5,000	.0120		
91,500	10,000	.0275		
	1,000		.0005	
137,250	15,000	.0430		
183,000	20,000	.0620		
	1,000		.0050	
188,000		.0650		
193,000		.0685		
198,000		.0710		
203,000		.0740		
208,000	22,730	.0780		Elastic limit.
213,000		.0830		
218,000		.0908		
223,000		.1065		
228,750	25,000	.1580		
	1,000		.0858	
233,000		.2060		
238,000		.347		
408,500	44,645			Ultimate strength.
0	0	7.62		=9.5 per cent.

Elongation in 5″ sections after fracture of bar: ″.50, ″.50, ″.47 ″.55, ″.48, ″.51, ″.49, ″.46, ″.46, 47, ″.46, ″.48, ″.47, ″.46, ″.48, ″.4.

No. 396.

Area at fracture, 2″.87×2″.87=8.24 square inches.

Contraction of area, 10 per cent.

Broke 42″.50 from end. Appearance granular. Similar to fracture of end No. 395.

Eight cracks along one surface developed by test. Maximum crack, 3″ long × $\frac{1}{2}$″ deep.

Small piece, about 1 ounce weight, flew out at point of fracture when specimen broke.

WROUGHT IRON—ROUND BARS.

Tests to determine the modulus of elasticity in the same bars for strains of tension and compression.

Bars of Phoenix and Pencoyd iron, cut in two at middle; one end strained by tension, and one end by compression.

These bars were taken from the same lot of iron that was used for the transverse strength of pins. (See report of tests, 1881.

No. 333.

PHŒNIX IRON—ROUGH BAR.

2$\frac{1}{2}$″ diameter, turned down to about 2″ diameter.

Actual diameter, 2.″003.

Sectional area, 3.142 square inches.

Gauged length, 30″.

TENSILE LOADS.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,142	1,000	0.		
15,710	5,000	.0040		
25,136	8,000	.0070		
31,420	10,000	.0090		
	1,000		0	
37,704	12,000	.0114		
47,130	15,000	.0140		E=30,000,000.
	1,000		0	

COMPRESSION LOADS.

Pounds per square inch.	Compression.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0050	.....	
8,000	.0076	.....	
10,000	.0096	.....	
1,000	.....	.0005	
12,000	.0116	.....	
15,000	.0150	.....	
1,000	.....	.0010	

In reversing the load from 1,000 pounds per square inch tension to 1,000 pounds per square inch compression, the gauge showed a movement of ".0020.

NOTE.—Deducting the permanent set ".001 from the compression at 15,000 pounds per square inch, and we find a modulus of elacticity the same as for tension.

TENSION LOADS.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch*	
3,142	1,000	0.	.....	
15,710	5,000	.0040	.....	
25,136	8,000	.0075	.....	
31,420	10,000	.0095	.....	
.....	1,000	.....	.0005	
37,704	12,000	.0115	.....	
47,130	15,000	.0148	.....	
.....	1,000	.....	.0004	

COMPRESSION LOADS.

Pounds per square inch.	Compression.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0044	.....	
8,000	.0076	.....	
10,000	.0096	.....	
1,000	.....	.0004	
12,000	.0116	.....	
15,000	.0149	.....	
1,000	.....	.0004	

The gaugings in last test were taken with the "friction dial" measuring instrument. To verify these measurements the screw micrometer is now placed on the specimen.

TENSION LOADS.

Pounds per square inch.	Elongation.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	Test resumed after bar had rested under zero load sixty-two hours.
5,000	.0045	.....	
8,000	.0078	.....	
10,000	.0099	.....	
1,000	.....	.0009	
12,000	.0122	.....	
15,000	.0154	.....	
1,000	.....	.0010	

COMPRESSION LOADS.

Pounds per square inch.	Compression.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0040	.....	
8,000	.0070	.....	
10,000	.0092	.....	
1,000	.....	.0001	
12,000	.0121	.....	
15,000	.0142	.....	
1,000	.....	.0001	

No. 334.

PHŒNIX IRON.

Off same bar as No. 333.
2¼″ rough bar turned down to 2″.003.
Sectional area, 3.142 square inches.
Gauged length, 30″.

COMPRESSION LOADS.

Pounds per square inch.	Compression.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0040	.....	
8,000	.0068	.....	
10,000	.0088	.....	
1,000	.....	—.0002	
12,000	.0108	.....	
15,000	.0139	.....	E=29,800,000.
1,000	.....	—.0002	

TENSION LOADS.

Pounds per square inch.	Elongation.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0044	.....	
8,000	.0075	.....	
10,000	.0095	.....	
1,000	.....	.0007	
12,000	.0117	.....	
15,000	.0147	.....	E=29,580,000.
1,000	.....	.0005	

COMPRESSION LOADS.

Pounds per square inch.	Compression.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.	.....	
5,000	.0042	.....	
8,000	.0072	.....	
10,000	.0095	.....	
1,000	.....	.0005	
12,000	.0115	.....	
15,000	.0148	.....	
1,000	.....	.0005	

TENSION LOADS.

Pounds per square inch.	Elongation.	Permanent set.	Remarks.
	Inch.	*Inch.*	
1,000	0.		
5,000	.0040		
8,000	.0074		
10,000	.0095		
1,000		.0005	
12,000	.0115		
15,000	.0147		
1,000		.0005	

No. 335.

PENCOYD IRON.

2¼″ rough bar turned down to 1″.995 diameter.
Sectional area, 3.126 square inches.
Gauged length, 30″.

TENSION LOADS.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,126	1,000	0.		
15,630	5,000	.0044		
25,008	8,000	.0074		
31,260	10,000	.0094		
	1,000		.0004	
37,512	12,000	.0115		
46,890	15,000	.0144	—.0001	
	1,000			
	15,000	.0144		
	1,000		—.0002	
	15,000	.0144		
	1,000		0.	
	10,000	.0095		
	1,000		0.	
56,268	18,000	.0168		
62,520	20,000	.0185		
	1,000		—.0012	
	5,000	.0037		
	8,000	.0070		
	10,000	.0092		
	1,000		0.	
	1,000		0. +	After resting 5 minutes.
	1,000		—.0001	After resting 15 minutes.
	10,000	.0093		
	15,000	.0148		
	20,000	.0203		
	1,000		.0003	
68,770	22,000	.0210		
71,898	23,000	.0220		
75,024	24,000	.0231		
76,587	24,500	.0235		
78,150	25,000			Sustained momentarily.
	1,000		—.0014	Springing the micrometer will vary the reading permanently about ″.0003. In use this springing would not occur. The springing was done experimentally. Load sustained momentarily.
	25,000	.0240		
79,713	25,500	.0244		
81,276	26,000	.0249		
82,839	26,500	.0255		
84,402	27,000	.0262		
85,965	27,500	.0271		
87,528	28,000			
	1,000		—.0006	

REMARKS.—It has been observed in the test of some flat rolled bars that permanent sets caused by loads of 10,000 pounds per square inch, or about that, were eliminated by higher strains, and, also, there has in a few cases appeared a permanent shortening

after the bar had been elongated. The apparent shortening was attributed to straightening of the bars in previous tests where this behavior occurred.

In the present instance, with a carefully turned bar, such an explanation as the above is obviously inadmissible. It would now appear that the above bar had initial strains which were released or some molecular arrangement broken up at 15,000 pounds per square inch, which enabled the bar to recover its original length upon the removal of that load, and even contract slightly, giving a minus sign to the permanent set.

This behavior is more marked after the bar was strained 20,000 pounds per square inch.

The measuring instrument, a micrometer screw, was carefully inspected to see that an instrumental error was not the cause of the minus permanent sets, but the instrument was found in good condition.

In corroboration of the micrometer measuring instrument, the scale beam of the testing-machine gave indication that a shortening of the specimen took place immediately after the strains were reduced to the initial load of 1,000 pounds per square inch.

After six months' rest, bar tested to the ultimate breaking strength = 163,800 pounds = 52,400 pounds per square inch.

Diameter of fracture, 1″.54 = 1.86 square inches; contraction of area, 40.5 per cent.; appearance fibrous, with slight granulation.

No. 336.

PENCOYD IRON.

Off same bar as No. 335.
Diameter, 2″.000.
Sectional area, 3.142 square inches.
Gauged length, 30″.
Friction dial used for measurement.

TENSION LOADS.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,142	1,000	0.	.....	
15,710	5,000	.0042	.....	
25,136	8,000	.0075	.....	
31,420	10,000	.0098	.....	
.....	1,000	.....	.0001	
37,704	12,000	.0120	.....	
47,130	15,000	.0150	.....	
.....	1,000	.....	0.	
56,556	18,000	.0179	.....	
62,840	20,000	.0194	.....	
.....	1,000	.....	—.0008	
72,266	23,000	.0223	.....	
.....	1,000	.....	—.0010	
78,550	25,000	.0243	.....	
.....	1,000	.....	—.0012	

In the test of No. 336 another measuring instrument was used—the friction dial instrument.

This bar, which was cut off the end of No. 335, showed a similar behavior to it, and as the dial-measuring instrument and the scale beam again in this case pointed to the same result, it is believed that a permanent shortening of the specimens did actually take place after loads between 15,000 pounds per square inch and 25,000 pounds per square inch had been applied and released.

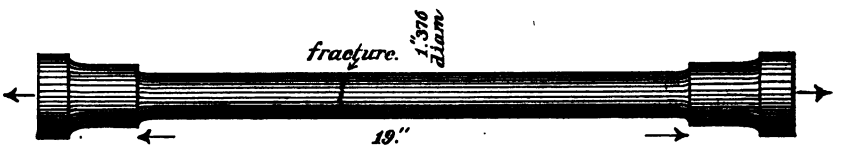
No. 354.

CAST IRON.

Tensile test of cast (gun) iron from South Boston Iron Company.

Mark on specimen: "No. 5, Block B."

FORM OF TEST PIECE.



Sectional area, 1.5 square inches.
Gauged length, 15".

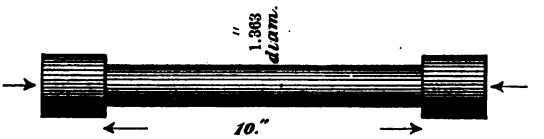
Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,500	1,000	—.0003	0.	
3,000	2,000	.0005	0.	
4,500	3,000	.0014	0.	
6,000	4,000	.0020	0.	
7,500	5,000	.0030	0.	
9,000	6,000	.0040	0.	
10,500	7,000	.0050	.0003	
12,000	8,000	.0060	.0005	
13,500	9,000	.0070	.0005	
15,000	10,000	.0083	.0005	
16,500	11,000	.0094	.0006	
18,000	12,000	.0105	.0007	
19,500	13,000	.0120	.0013	
21,000	14,000	.0133	.0015	
22,500	15,000	.0147	.0019	
24,000	16,000	.0164	.0025	
25,500	17,000	.0180	.0030	
27,000	18,000	.0204	.0036	
28,500	19,000	.0224	.0045	
30,000	20,000	.0250	.0059	
31,500	21,000	.0285	.0080	
33,000	22,000	.0325	.0105	
34,500	23,000	.0380	.0145	
36,000	24,000	.0446	.0195	
37,500	25,000	.....	.....	Ultimate strength.

Broke $1\frac{3}{4}$" from middle of bar.

No. 355.

Compression test of cast (gun) iron from South Boston Iron Company.

Mark on specimen: "No. 5, Block. A."



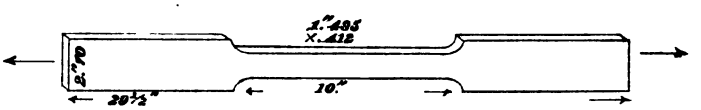
Sectional area, 1.46 square inches.
Gauged length, 10".

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,460	1,000	.0005	0.	
2,920	2,000	.0016	0.	
4,380	3,000	.0018	0.	
5,840	4,000	.0025	.0002	
7,300	5,000	.0030	.0005	
8,760	6,000	.0040	.0005	
10,220	7,000	.0045	.0005	
11,680	8,000	.0050	.0005	
13,140	9,000	.0060	.0006	
14,600	10,000	.0074	.0007	
16,060	11,000	.0075	.0008	
17,520	12,000	.0080	.0010	
18,980	13,000	.0082	.0010	
20,440	14,000	.0090	.0010	
21,900	15,000	.0100	.0010	
23,360	16,000	.0105	.0012	
24,820	17,000	.0105	.0012	
26,280	18,000	.0113	.0010	
27,740	19,000	.0125	.0010	
29,200	20,000	.0130	.0015	
30,660	21,000	.0140	.0014	
32,120	22,000	.0150	.0020	
33,580	23,000	.0158	.0019	
35,040	24,000	.0165	.0030	
36,500	25,000	.0174	.0030	
37,960	26,000	.0185	.0030	
39,420	27,000	.0200	.0032	
40,880	28,000	.0205	.0048	
42,340	29,000	.0225	.0048	
43,800	30,000	.0234	.0054	
45,260	31,000	.0251	.0068	
46,720	32,000	.0270	.0076	
48,180	33,000	.0290	.0092	
49,640	34,000	.0310	.0110	
51,100	35,000	.0332	.0130	
52,560	36,000	.0359	.0150	
54,020	37,000	.0400	.0180	
55,480	38,000	.0427	.0205	
56,940	39,000	.0475	.0242	
58,400	40,000	.0516	.0280	
108,800	74,520	.....	.....	Ultimate strength.

SHAPE AFTER FRACTURE.

No. 382.

Tensile test of gun-metal (bronze) used in cavalry forge cart—details.



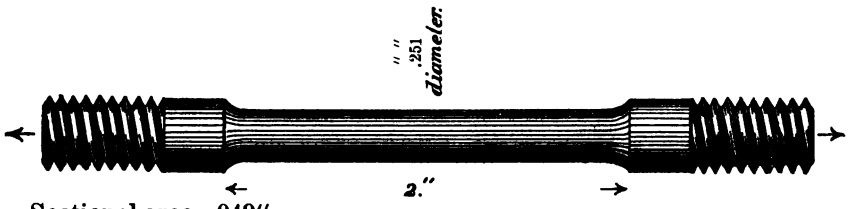
Sectional area, .616 square inch.
Gauged length, 10″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
5,000		0.		Elongations measured from load of 5,000 pounds.
6,000		.0013		
7,000		.0028		
8,000		.0042		
9,000		.0061		
9,800	15,910			Elastic limit.
10,000		.0082		
5,000			.0019	
10,500		.0100		
11,000		.0116		
11,500		.0140		
12,000		.0176		
12,500		.0200		
5,000			.0100	
13,000		.0239		
14,000		.0340		
15,400		.0496		
18,900	30,680			Ultimate strength.
0	0	.15		= 1.5 per cent.

Broke, about $\frac{1}{4}''$ from curve of neck.
Fracture, dull color.
Fractured, with slight contraction.

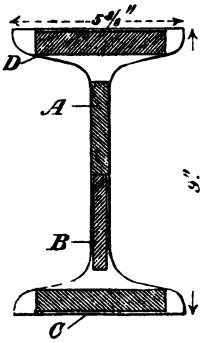
No. 383.

Tensile test of gun-metal cut from nave, cavalry forge cart.



Sectional area, .049″.
Ultimate strength, 1,605 pounds = 32,760 pounds per square inch.
Broke about $\frac{1}{16}''$ from middle of specimen.
Elongation about ″.29 in 2″ = $14\frac{1}{2}$ per cent.
Fracture bright, varying in color.

Test of a 9″ wrought-iron I beam by strains of tension and compression.



Tensile specimens *A*, *B*, *C*, and *D* cut out of beam, as shown by the sketch.

Specimen *A* has planed edges and rough sides. Specimens *B*, *C*, and D are planed on all faces. Specimen *E* compression test of the full section of beam.

No. 337.

Tensile test of Specimen A.

Size of bar, 3″ × ″.65 = 1.95 square inches.
Gauged length, 30″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,950	1,000			
9,750	5,000	.0044		
15,600	8,000	.0077		
19,500	10,000	.0099		
	1,000		0.	
23,400	12,000	.0120		
29,250	15,000	.0153		
	1,000		0.	
35,100	18,000	.0189		
39,000	20,000	.0211		
	1,000		.0009	
40,950	21,000	.0227		
42,900	22,000	.0237		
44,850	23,000	.0249		
46,800	24,000	.0260		
48,750	25,000	.0277		E = 28,347,000.
	1,000		.0019	
50,700	26,000	.0290		
52,650	27,000	.0308		
54,600	28,000	.0320		
56,550	29,000	.0339		
58,500	30,000	.0361		
	1,000		.0049	
60,450	31,000	.0389		
62,400	32,000	.0417		
	32,000	.0427		After 3 minutes rest.
	32,000	.0429		After 5 minutes rest.
64,350	33,000	.0449		
66,300	34,000	.0487		
68,250	35,000	.0559		
70,200	36,000	.065		Yielding still continuing.
103,300	52,970			Ultimate strength.
0	0	2 24		= 7.5 per cent.

Fractured 1″ outside of gauged length.
Appearance of fractures: Granular, 92 per cent.; fibrous, 8 per cent.
Area at fracture, 2″.92 × ″.60 = 1.752 square inches.
Contraction of area, 10 per cent.

No. 341.

Tensile test of Specimen B.

Size of bar, 3″ × ″.503 = 1.509 square inches.
Gauged length, 30″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,509	1,000	0.		
9,545	5,000	.0060		
12,072	8,000	.0080		
15,090	10,000	.0101		
	1,000		0.	
18,108	12,000	.0122		
24,635	15,000	.0170		

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
.....	1,000	.....	.0001	
27,162	18,000	.0190	.....	
30,180	20,000	.0215	.....	
.....	1,000	.....	.0008	
33,198	22,000	.0242	.....	
36,216	24,000	.0270	.....	
37,725	25,000	.0285	.....	E=27,376,000.
.....	1,000	.....	.0022	
39,234	26,000	.0302	.....	
40,743	27,000	.0321	.....	
42,252	28,000	.0340	.....	
43,761	29,000	.0368	.....	
45,270	30,000	.0398	.....	
.....	1,000	.....	.0080	
46,779	31,000	.0440	.....	
48,288	32,000	.0482	.....	
49,797	33,000	.0542	.....	
51,306	34,000	.065	.....	Yielding continues; stretch not all taken out which this load would cause.
65,400	43,340	.....	.....	Ultimate strength.
0	0	.78	.....	=2.6 per cent.

Area at fracture, 2″.96 × ″.49 = 1.45 square inches; contraction of area, 3.9 per cent.

Fracture: Granular, 95 per cent.; fibrous, 05 per cent.

Appearance of bar not clean; seamy.

No. 342.

Tensile test of Specimen C.

Size of bar, 4″.003 × ″.752 = 3.01 square inches.

Gauged length, 30″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,010	1,000	0.	.....	
15,050	5,000	.0046	.....	
24,080	8,000	.0078	.....	
30,100	10,000	.0102	.....	
.....	1,000	.....	.0008	
36,120	12,000	.0128	.....	
45,150	15,000	.0159	.....	
.....	1,000	.....	.0009	
54,180	18,000	.0199	.....	
60,200	20,000	.0238	.....	E=28,500,000.
.....	1,000	.....	.0038	
66,220	22,000	.0296	.....	
72,240	24,000	.0399	.....	
75,250	25,000	.0518	.....	
.....	1,000	.....	.0256	
146,400	48,640	.....	.....	Ultimate strength.
0	0	5.25	.....	=17.5 per cent.

Area at fracture, 3″.67 × ″.66 = 2.42 square inches.

Contraction of area, 19.6 per cent.

Fibrous fracture, good appearance.

Began to break on one edge, extending across.

No. 343.

Tensile test of Specimen D.

Size of bar, $4'' \times .756 = 3.024$ square inches.
Gauged length, 30″.

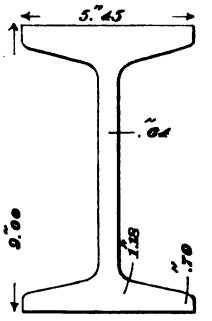
Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,024	1,000	.0		
15,120	5,000	.0044		
24,192	8,000	.0077		
30,240	10,000	.0099		
	1,000		.0001	
	1,000		.0001	
36,288	12,000	.0117		
45,360	15,000	.0151		
	1,000		.0001	
54,432	18,000	.0186		
60,480	20,000	.0211		E = 28,078,000.
	1,000		.0008	
66,528	22,000	.0254		
69,552	23,000	.0276		
72,576	24,000	.0306		
75,600	25,000	.0357		
	1,000		.0106	
78,624	26,000	.0431		Yielding continues.
81,648	27,000	.0590		Do.
147,100	48,640			Ultimate strength.
0	0	3.95		= 13.2 per cent.

Area at fracture, $3''.74 \times .68 = 2.543$ square inches.
Contraction of area, 15.9 per cent.
Fracture: Fibrous, 90 per cent; granular, 10 per cent.
Fracture began at edge of bar.
This bar was not straight—slightly concave on the side that measurements of elongation were taken.

No. 344.

Test by compression of I *beam.*

SPECIMEN E.



Total length, 57″.06.
Weight, 228 pounds.
Sectional area, 14.4 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
14,400	1,000	0.		
72,000	5,000	.0058		
115,200	8,000	.0108		
144,000	10,000	.0142		
	1,000		.0014	
	10,000	.0145		
	1,000		.0014	
172,800	12,000	.0175		
216,000	15,000	.0230		
	1,000		.0010	
	15,000	.0230		
	1,000		.0014	
259,200	18,000			
288,000	20,000	.0330		E = 31,250,000.
	1,000		.0026	
	18,000	.0298		
	20,000	.0330		
	1,000		.0026	
316,800	22,000	.0370		
345,600	24,000	.0415		
360,000	25,000	.0440		
	1,000		.0059	
374,400	26,000	.0475		
388,800	27,000	.0500		
403,200	28,000	.0534		
417,600	29,000	.0585		
432,000	30,000	.0630		
	30,000	.0660		After 5 minutes' rest.
	1,000		.0195	
460,800	32,000	.0835		
	32,000	.0922		After 4 minutes' rest.
545,100	37,854			Ultimate strength.

Beam failed by horizontal deflection, or in the direction perpendicular to the web, beam taking triple flexure.

When deflection reached about 1″, the test was discontinued. The load the beam was sustaining at the time was 538,000 pounds.

10″ Wrought Iron I Beam.

(Rolled by Union Iron Company, Buffalo, N. Y.)

Tests by tension and compression.

No. 345.

Specimen planed out of flange of beam.
Dimensions, 48″ × 3″ × ″.51.
Sectional area, 1.53 square inches.
Gauged length, 30″.
Metal has poor appearance; porous.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,530	1,000	0.		
7,650	5,000	.0043		
12,240	8,000	.0076		
15,300	10,000	.0100		
	1,000		.0001	
18,360	12,000	.0121		
22,950	15,000	.0156		
27,540	18,000	.0192		
30,600	20,000	.0221		
	1,000		.0011	
43,700	28,560			Elastic limit.
55,400	36,210			Ultimate strength.
0	0	.65		= 2.2 per cent.

Area at fracture, 2″.90×″.47=1.36 square inches.
Contraction of area, 11.1 per cent.
Appearance of fracture, dull, spongy.

No. 346.

Specimen planed out of web of beam.
Dimensions, 48″×3″×″.395.
Sectional area, 1.185 square inches.
Gauged length, 30″.

Loads applied.	Pounds per square inch.	Elongation.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
1,185	1,000	0.		
5,925	5,000	.0042		
9,480	8,000	.0072		
11,850	10,000	.0097		
	1,000		.0003	
14,220	12,000	.0122		
17,775	15,000	.0153		
21,330	18,000	.0191		
23,700	20,000	.0213		
	1,000		.0014	
29,900	25,230			Elastic limit.
52,900	44,640			Ultimate strength.
0	0	2.17		= 7.2 per cent.

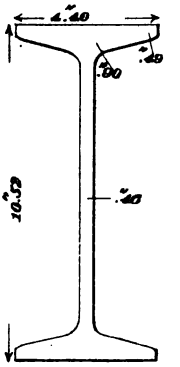
Area at fracture, 2″.90×″.34 = .99 square inch.
Contraction of area, 16.5 per cent.
Appearance at fracture dull, spongy; small granular spot.

No. 347.

Compression test of wrought iron.

I-BEAM.

Specimens No. 345 and No. 346 were cut off one end of this beam.



Tested with flat ends, counterweighted at middle.
Total length, 155″.45.
Total weight, 443 pounds.
Gauged length, 150″.
Sectional area, 10.26 square inches.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,260	1,000	0.	.....	0.	0.	
51,300	5,000	.0185	.....	0.	0.	
102,600	10,000	.0440	.....	0.	.02	
.....	1,000	0.	0.	0.	0.	
123,120	12,000	.0542	.....	.05	.02	
153,900	15,000	.0694	.....	.10	.02	
.....	1,000	.....	0.	0.	0.	
184,680	18,000	.0846	.....	.15	.05	
205,200	20,000	.0962	.....	.30	.10	
.....	1,000	.....	— .0002	.09	.06	
207,000	20,170	.....	.....	.....	.....	Ultimate strength.

Failed by horizontal deflection.
Took sharp bend at middle.

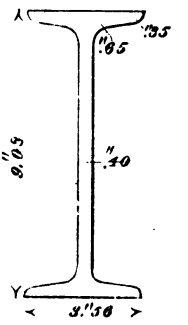
Compression tests of wrought-iron I beams.

Flat ends. Placed in testing machine with webs vertical.

No. 348.

9″ I BEAM.

(Rolled by Union Iron Company, Buffalo, N. Y.)



$r = .69$

$\frac{l}{r} = 218$

Total length, 191″.90.
Total weight, 365 pounds.
Sectional area, 6.85 square inches.
Gauged length, 150″.

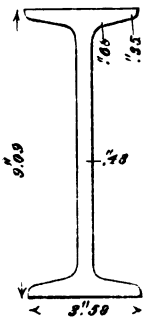
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,850	1,000	0.	.....	0.	0.	
34,250	5,000	.0215	.....	— .07	0.	
54,800	8,000	.0380	.....	— .11	.05	
68,500	10,000	.0501	.....	— .20	.06	
.....	1,000	.....	0.	0.	0.	
82,200	12,000	.0665	.....	— .43	.04	
85,380	12,460	.....	.....	— .78	0.	Ultimate strength.

After passing the ultimate load, strains were continued, the horizontal deflection increasing rapidly, but not with a sudden spring.

When the horizontal deflection had reached 3″.7, the load sustained was 40,000 pounds.

No. 349.

Duplicate of beam No. 348.



Total length, 191″.90.
Total weight, 381 pounds.
Gauged length, 150″.
Sectional area, 7.15 square inches.

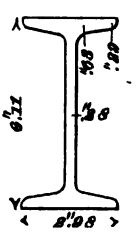
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,150	1,000	0.	.....	0.	0.	
35,750	5,000	.0208	.....	— .07	0.	
57,200	8,000	.0375	.....	— .13	0.	
71,500	10,000	.0495	.....	— .25	0.	
.....	1,000	.....	0.	0.	0.	
85,200	[illegible]	.....	.....	— .82	0.	Ultimate strength.

Failed by horizontal deflection.

No. 350.

6″ I BEAM.

(Rolled by Union Iron Company.)



Length, 119″.85.
Weight, 139 pounds.

Sectional area, 4.18 square inches.
Gauged length, 100″.

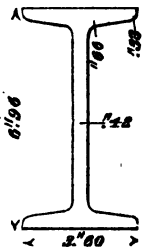
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
4,180	1,000	0.	.....	0.	0.	
20,900	5,000	.0130	.....	0.	0.	
33,440	8,000	.0234	.....	— .01	0.	
41,800	10,000	.0302	.....	— .03	0.	
.....	1,000	.....	0.	0.	0.	
50,160	12,000	.0372	.....	— .03	0.	
101,200	24,210	.....	.....	— .60	.....	Ultimate strength.

Failed by horizontal deflection.

No. 351.

7″ I BEAM.

(Rolled by Union Iron Company.)



$n = .14$

$\frac{l}{n} = 244$

Total length, 180″.33.
Total weight, 303 pounds.
Sectional area, 6.05 square inches.
Gauged length, 150″.

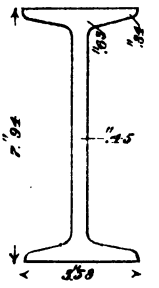
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,050	1,000	0.	.....	0.	0.	
30,250	5,000	.0270	.....	— .08	— .03	
48,400	8,000	.0445	.....	— .15	— .04	
60,500	10,000	.0570	.....	— .23	— .04	
.....	1,000	.....	.0006	0.	0.	
76,200	12,000	.0761	.....	— .43	— .04	
84,650	13,990	.....	.....	— .95	— .02	Ultimate strength.

Failed by horizontal deflection.

No. 352.

8″ I BEAM.

(Rolled by Union Iron Company, Buffalo, N. Y.)



Total length, 192″.04.
Total weight, 355 pounds.
Sectional area, 6.65 square inches.
Gauged length, 150″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,650	1,000	0.	.....	0.	0.	
33,250	5,000	.0190	.....	+ .07	— .02	
53,200	8,000	.0340	.....	.11	— .04	
6,650	10,000	.0430	.....	.16	— .04	
.....	1,000	.....	— .0010	.04	0.	
Released strain and changed packing behind the ends.						
.....	1,000	0.	0.	0.	0.	New gaugings began.
.....	5,000	.0210	.....	0.	0.	
.....	8,000	.0372	.....	— .05	0.	
.....	10,000	.0485	.....	— .12	0.	
.....	1,000	.....	0.	0.	0.	
79,800	12,000	.0630	.....	— .35	0.	
83,400	12,540	.....	.....	—1.05	0.	Ultimate strength.

Failed by horizontal deflection.

No. 353.

8″ BEAM.

Duplicate of No. 352.

Total length, 192″.90.
Total weight, 353 pounds.
Sectional area, 6.59 square inches.
Gauged length, 150″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,590	1,000	0.	.. ..	0.	0.	
32,950	5,000	.0212	.....	0.	— .06	
52,720	8,000	.0368	.....	0.	— .10	
65,900	10 000	.0470	.....	0.	— .10	
.....	1,000	.....	— .0002	0.	— .04	
79,080	12,000	.0570	.....	0.	— .10	
92,300	14,010	.....	.....	+ .50	— .10	Ultimate strength.

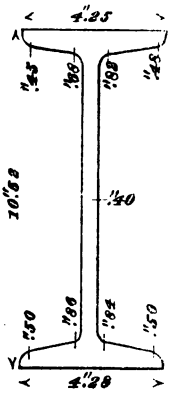
Failed by horizontal deflection.

After the ultimate load had been passed and the deflection had reached about 1″.25, the beam suddenly sprung laterally.

No. 356.

10″ Wrought Iron I Beam.

(Rolled by Union Iron Company, Buffalo, N. Y.)



$r = .90$

$\frac{l}{r} = 240$

Total length, 215″.88.

Gauged length, 200″.

Weight, 561 pounds.

Sectional area, 9.3 square inches.

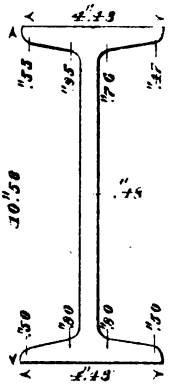
Counterweighted at middle. Ends did not come to good bearing; required about ″.05 brass packing; maximum amount.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
9,300	1,000	0.	.....	0.	0.	
46,500	5,000	.0271	.....	0.	0.	
74,400	8,000	.0490	.....	0.	—.02	
93,000	10,000	.0665	.....	0.	—.04	
9,300	1,000	.....	.0050	0.	—.02	
111,600	12,000	.0844	.....	— .08	—.06	
120,900	13,000	.0940	.....	— .05	—.06	
130,200	14,000	.1029	.....	— .08	—.06	
139,500	15,000	.1125	.....	— .17	—.06	
9,300	1,000	.....	.0150	0.	—.04	
149,000	16,020	.....	.....	— .70	—.05	
.....	.....	.....	.....	—1.20	.....	Ultimate strength.
9,300	1.000	.....	.....	— .20	.....	Maximum deflection.

No. 357.

10″ I BEAM.

(Union Iron Company, Buffalo, N. Y.)



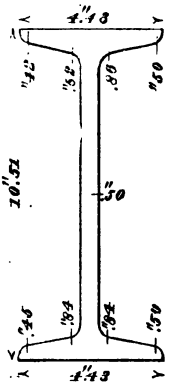
Total length, 264″.08.
Gauged length, 250″.
Sectional area, 10.19 square inches.
Weight, 747 pounds.
Counterweighted at middle.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,190	1,000	0.	.....	0.	0.	
50,950	5,000	.0335	.....	+ .07	+ .02	
81,520	8,000	.0604	.....	.12	.03	
101,900	10,000	.0785	.....	.25	.03	
.....	1,000	.....	.0020	.03	.02	
113,100	11,100	.....	.....	1.00	.03	Ultimate strength.
.....	1,000	.....	.....	.08	.02	

No. 358.

10″ I BEAM.

(Union Iron Company, Buffalo, N. Y.)



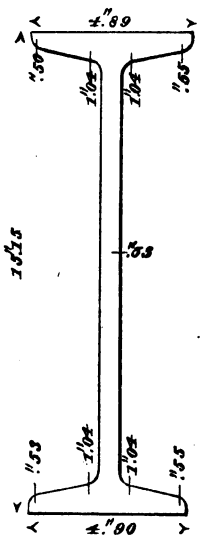
Total length, 264″.08.
Gauged length, 250″.
Sectional area, 10.46 square inches.
Weight, 767 pounds.
Counterweighted at middle.
Ends come to a good bearing.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,460	1,000	0.	.....	0.	0.	
52,300	5,000	.0356	.....	.20	0.	
83,680	8,000	.0629	.....	.23	0.	
104,600	10,000	.0820	.....	.70	0.	
.....	1,000	.....	0.	0.	0.	
107,800	10,306	.....	.....	1.14	0.	Ultimate strength.
.....	1,000	.....	.....	.05	0.	
		Per deflection increased.				
.....	1,000	.....	.....	.36	0.	
82,000	.....	.....	.....	3.00	.....	Sustains after above per deflection.

No. 359.

15″ WROUGHT-IRON I BEAM.

(Union Iron Company, Buffalo, N. Y.)



$r = .95$

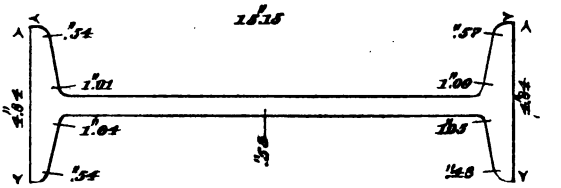
$\frac{l}{r} = 278$

Total length, 264″.
Gauged length, 250″.
Sectional area, 14.8 square inches.
Weight, 1,085 pounds.
Counterweighted at middle.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
14,800	1,000	0.	.....	0.	0.	
74,000	5,000	.0350	.....	0.	0.	
118,400	8,000	.0612	.....	0.	0.	
148,000	10,000	.0852	.....	— .07	0.	
.....	1,000	.....	.0060	0.	0.	
177,600	12,000	.....	.....	— .20	0.	
184,700	12,400	.....	.....	— .70	0.	Ultimate strength.

No. 360.

WROUGHT-IRON I BEAM.



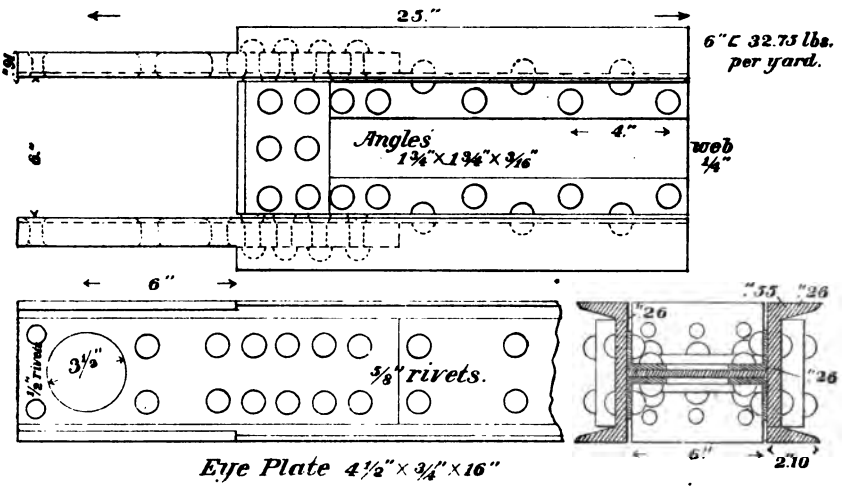
Total length, 263″.95.
Gauged length, 250″.
Sectional area, 14.74 square inches.
Weight, 1,081 pounds.
Counterweighted at middle.
Ends come to good bearing without packing.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
14,740	1,000	0.	.....	0.	0.	
73,700	5,000	.0365	.....	0.	0.	
117,920	8,000	.0635	.....	0.	0.	Snapping sounds heard when load exceeded 8,000 pounds per square inch.
147,400	10,000	1.0920	.....	+ .02	0.	
.....	1,000	.....	.0130	0.	0.	
176,880	12,000	.....	.....	.08	0.	
187,000	12,686	.....	.....	.70	0.	Ultimate strength.

Compression of pin ends of wrought iron posts.

No. 391.

Tested with one pin end, one flat end.



Eye Plate 4½"×¾"×16"

Ultimate strength, 393,000 pounds.

Specimen tested with one pin end, one flat end. Pin in vertical position.

Post failed by deflecting perpendicular to axis of pin, buckling the flanges of the channel bars. The eye-plates were bent concave, and also the webs of channel bars, from the inside of the post.

Fracture of the channel-bar web occurred along one row of rivet holes, where riveted to eye-plate.

The pin ends were bent inward.

Strains were very gradually increased; yielding took place slowly.

No. 392.

Compression of short pin and post.

Duplicate of No. 391.

Ultimate strength, 415,000 pounds.

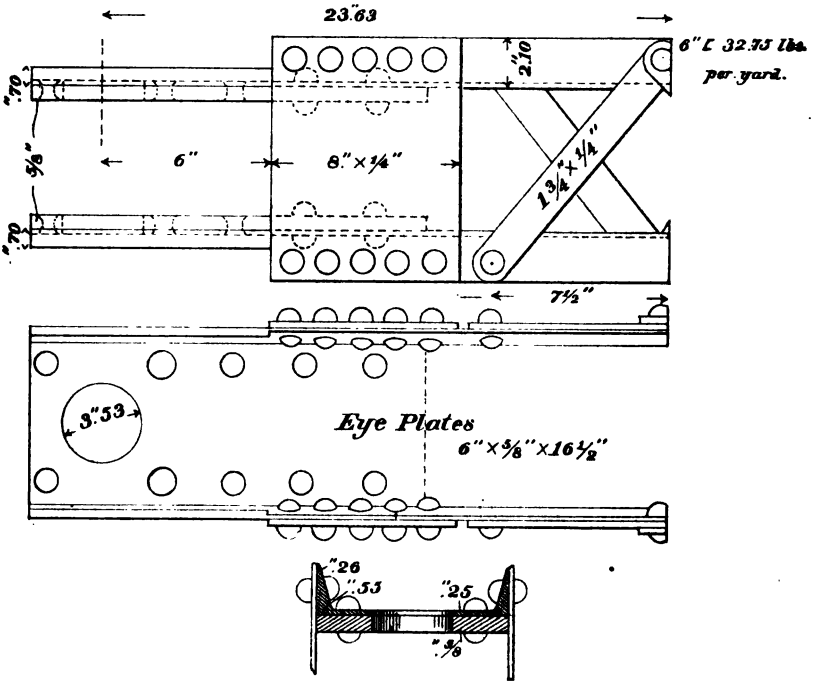
This post failed in a manner similar to No. 391, but without horizontal deflection. Each pin end bent inward. This failure occurred about the same time the channel-bar webs and eye-plates were bent concave from the inside of the post.

The concave bending of the webs was accompanied by outward buckling of the channel-bar flanges as far as the eye-plate reached.

Cripling was carried on till one channel-bar web cracked along the line of rivets which connects it to the eye-plate.

No. 393.

Tested with one pin end, one flat end.



$\frac{5}{8}$" rivets, except two end rivets, $\frac{1}{2}$" each.

Same size channels as used in Nos. 391 and 392, punched holes.

Ultimate strength, 302,600 pounds.

Post failed by buckling the web and flanges of channel bars between flat end and side plates.

Secondary bending took place at the pin end, after considerable buckling had been given the channel bars.

No. 394.

Duplicate of No. 393.

Ultimate strength, 302,200 pounds.

Failed the same as No. 393.

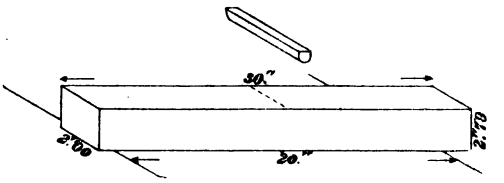
Slight bend of pin ends took place about the same time the channel bars buckled.

No. 361.

Transverse test of wrought-iron bar.

Hammered iron, very full of seams.

Specimen dressed all over.



End bearings 20″ apart.
Loaded at middle.
Middle bearing semicircular, ½″ radius.

Loads applied.	Δ	Δ set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
500	.0036	.....	Loads released to zero when measuring Δ sets.
1,000	.0044	.0001	
1,500	.0051	.....	
2,000	.0061	.....	
2,500	.0070	.....	
3,000	.0078	.0002	
4,000	.0097	.....	
5,000	.0116	.0002	
6,000	0131	.....	
7,000	.0148	.....	
8,000	.0154	.0003	
9,000	.0183	.....	
10,000	.0201	.....	
11,000	.0218	.....	
12,000	.0236	.0009	
13,000	.0257	.....	
14,000	.0279	.....	
15,000	.0301	.0023	
16,000	.0333	.....	
17,000	.0380	.0066	
18,000	.0551	.0220	
19,000	.0901	.....	
20,000	.1380	.1002	
21,000	.177	.....	
22,000	.226	.184	Micrometer removed.
23,000	.27	.....	
24,000	.35	.....	
25,000	.41	.....	
27,000	.55	.....	
30,000	.85	.....	
35,000	1.74	.....	
40,000	3.05	.....	
43,800	*5.5	.....	Ultimate strength.

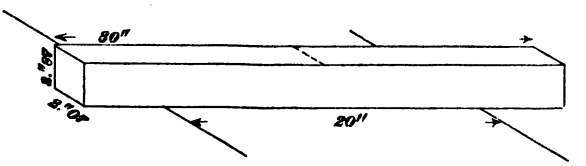
*About.

Test discontinued when the bar had been bent about 85°.
A 3″ section laid off on the tension side at the middle before the test began now measures 4″.27.
Elongation of outside fibers, 42 per cent.

No. 1590.

Transverse test of gun iron for South Boston Iron Company.

Specimen dressed all over.



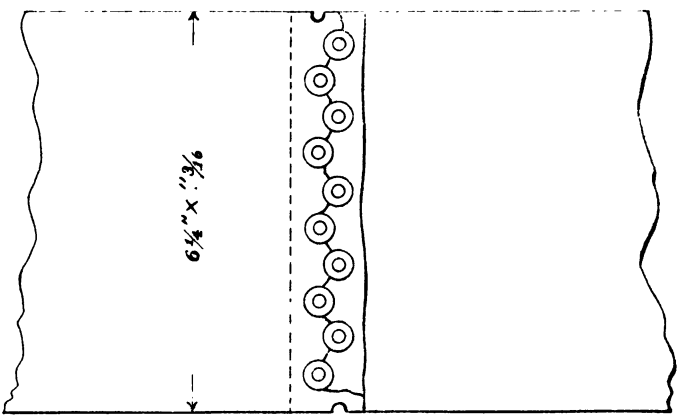
20″ between end supports.
Loaded at middle.
Middle bearing semicircular, ½″ radius.

Loads applied.	Δ	Δ set.	Remarks.
Pounds.	*Inch.*	*Inch.*	
500	.0017		Loads released to zero load when Δ sets were measured.
1,000	.0030	.0002	
1,500	.0040		
2,000	.0054	.0002	
2,500	.0070		
3,000	.0082	.0003	
3,500	.0088		
4,000	.0102	.0002	
4,500	.0112		
5,000	.0124	.0001	
5,500	.0137		
6,000	.0152	.0001	
6,500	.0160		
7,000	.0172	.0002	
7,500	.0183		
8,000	.0194	.0005	
8,500	.0207		
9,000	.0220	.0007	
9,500	.0230		
10,000	.0242	.0008	
10,500	.0257		
11,000	.0267	.0012	
11,500	.0299		
12,000	.0294	.0014	
12,500	.0304		
13,000	.0317	.0017	
13,500	.0332		
14,000	.0344	.0022	
14,500	.0357		
15,000	.0372	.0027	
15,500	.0387		
16,000	.0400	.0032	
17,000	.0427		
18,000	.0454	.0042	
19,000	.0487		
20,000	.0520	.0062	
21,000	.0554		
22,000	.0592	.0084	
23,000	.0630		
24,000	.0672	.0120	
29,600			Ultimate strength.

Tensile test of riveted joint in white-oak tanned hose leather.

Section of 3″ hose cut apart and joint tested.

No. 324.

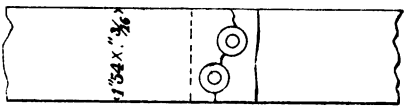


Gross sectional area of leather, 1.17 square inch.
Ten rivets about 2″ diameter.

Galvanized rivets and burrs.
Ultimate strength, 3,100 pounds = 2,650 pounds per square inch on gross section.
Fractured first through middle sections of joint.
Fracture occurring on side of joint having burrs.
Heads of rivets cup-shaped; burrs flat.

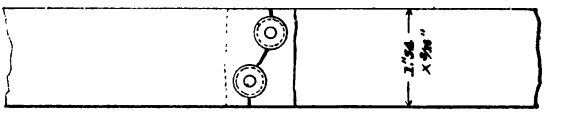
No. 325.

Specimen made from same leather as No. 324.



Two rivets, with flat heads and flat burrs.
Galvanized rivets and burrs.
Ultimate strength, 640 pounds.
Fractured leather next rivet heads.
Fractures began at rivet holes.

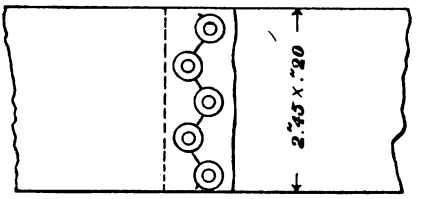
No. 326.



Two rivets, with cup shaped heads and burrs.
Galvanized rivets.
Ultimate strength, 670 pounds.
Fractures began at rivet holes.
Tore leather on burr side of specimen.

No. 611.

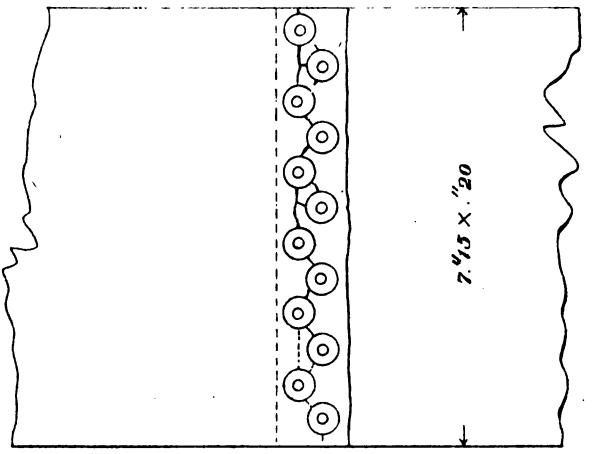
Old specimen of leather hose.



Five rivets, about ".21 diameter, copper, galvanized.
Leather about rivets coated with verdigris.
Ultimate strength, 1,280 pounds = 256 pounds per rivet.
Fractured on the burr side of joint, beginning at middle of specimen.

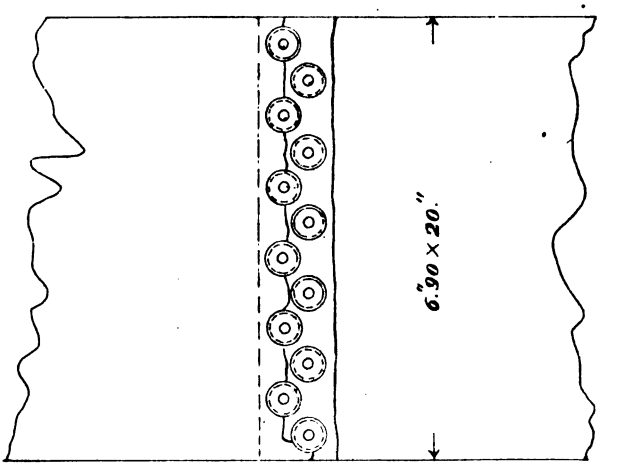
No. 612.

New specimen of leather hose.



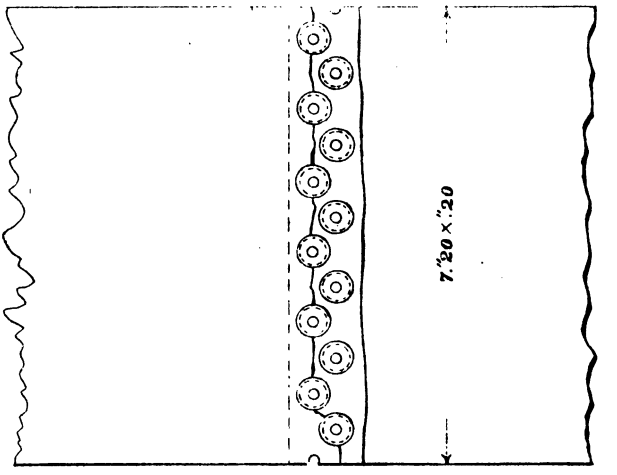
Twelve rivets, with flat heads and flat burrs.
Rivets and burrs copper, galvanized.
Ultimate strength, 4,050 pounds = 337 pounds per rivet.
Fractures began at each side, on the burr side tearing across four rivet holes.
Opposite side of joint tearing across nine rivet holes.

No. 613.



Twelve copper rivets, with cup-shaped heads and cup-shaped burrs; heads galvanized.
Copper burrs not galvanized.
Ultimate strength, 4,210 pounds = 351 pounds per rivet.
Fractured across specimen through one row of rivet holes on the burr side of the joint.

No. 614.



Twelve copper rivets, with cup-shaped heads and burrs.
Rivets galvanized, burrs made of brass, not galvanized.
Ultimate strength, 4,380 pounds = 365 pounds per rivet.
Specimen fractured on the side of the rivet heads, the fracture beginning at one edge and tearing across through one row of rivet holes.
Specimens Nos. 612, 613, and 614 made from the same piece of leather.

Compression of cast iron.

DESCRIPTION OF CASTINGS.

. indicates Providence gun iron, dry sand slack heating.
. . indicates Providence gun iron, dry sand hot.
. . . indicates gray iron, dry sand.
. . . . indicates gray iron, wet sand.
Bars cylindrical, in the condition they came from the molds, ends faced off.
Tested between flat steel faces.

No. 363.

Mark on bar, .
Length, 14″.95.
Diameter, 1″.75.
Sectional area, 2.4 square inches.
Ultimate strength, 149,200 pounds = 62,170 pounds per square inch.

No. 364.

Mark on bar, . .
Length, 14.″97.
Diameter, 1″.77.
Sectional area, 2.46 square inches.
Ultimate strength, 167,400 pounds = 68,050 pounds per square inch.

No. 365.

Mark on bar, . . .

Length, 13″.98.
Diameter, 1″.75.
Sectional area, 2.4 square inches.
Ultimate strength, 158,000 pounds = 65,830 pounds per square inch.

No. 366.

Mark on bar, ...

Length, 14″.97.
Diameter, 1″.76.
Sectional area, 2.43 square inches.
Ultimate strength, 198,000 pounds = 81,810 pounds per square inch.

Indentation of copper with circular indenting tool.

[Three cuts made in each copper.]

Number of experiment.	Mark on copper.	Size of copper. Length.	Width.	Thickness.	Pounds pressure on indenting tool.	Length of cut.	Mean length of cut.	Remarks.
		Inch.	*Inch.*	*Inch.*		*Inch.*	*Inch.*	
367	A	.94	1.6	.48	500 500 500	.50– .49 .50–	.497	
368	B	.94	1.6	.48	750 750 750	.58½ .58 .58½	.583	
369	C	.96	1.6	.48	1,000 1,000 1,000	.64½ .63½ .64	.64	
370	D	1.04	1.6	.48	1,250 1,250 1,250	.71 .70– .70½	.705	
371	E	1.10	1.6	.48	1,500 1,500 1,500	.75 .73 .75–	.743	Perceptible swelling of the sides of coppers.
372	F	1.23	1.6	.48	2,000 2,000 2,000	.84½ .83½ .84	.84	
373	H	1.43	1.6	.48	2,500 2,500 2,500	.90½ .89 .90	.898	
374	G	1.44	1.6	.48	3,000 3,000 3,000	.98 .95 .96	.963	
375	I	1.52	1.6	.48	1,500 3,500 3,500	1.02 1.00 1.02	1.01+	
376	J	1.52	1.6	.48	4,000 4,000 4,000	1.08½ 1.06 1.08	1.07½	
377	K	1.54	1.6	.48	4,500 4,500 4,500	1.12½ 1.10– 1.12½	1.117	
378	L	1.69	1.6	.48	5,000 5,000 5,000	1.17½ 1.14½ 1.17–	1.163	
379	M	1.84	1.6	.48	6,000 6,000 6,000	1.25 1.21 1.23	1.23	
380	N	1.90	1.6	.48	7,000 7,000 7,000	1.31 1.27½ 1.29½	1.293	
381	O	1.99	1.6	.48	8,000 8,000 8,000	1.37½ 1.33½ 1.35½	1.355	

The lengths are recorded in the order they were made. The cuts were spaced so as to divide the width of each copper into four equal (or nearly so) parts.

An outside cut was made first, then the middle cut, and finally an outside cut.

REMARKS ON THE COMPRESSION TESTS OF TIMBER POSTS.

Posts were tested in a horizontal position between flat cast-iron platforms. Those of rectangular cross-section were placed in the testing-machine with their longer sides vertical.

The vertical dimension is recorded in the notes as depth of post; the horizontal dimension, width of post.

To insure straightness the sticks were dressed immediately before testing. Such as were found badly warped before dressing were measured, and the amount of deflection recorded on the sketches. The letter *c* in connection with figures shows how much the stick was concave on that side. The letter *x* shows that the side to which it refers was convex before dressing. It was intended to determine whether the distortion of seasoning fixed the direction of deflection when tested as a post.

The deflections while under test were indicated by a pointer secured to the middle of the post and having an arm about 24″ long, reaching out to a dial secured to one of the main screws of the testing-machine.

It was observed that many sticks took an apparent deflection in the direction parallel to their longer side. This led to the employment of a pointer about 48″ long, which was secured at its middle to the post.

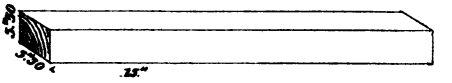
Readings taken on each side showed that the posts frequently had a spiral movement when loaded.

Compressions were measured within the gauged length. The ends of the measuring rods were secured in center punch-marks in the heads of screws driven in the wood.

The direction of the rings of yearly growth are correctly represented on the sketches of the specimens.

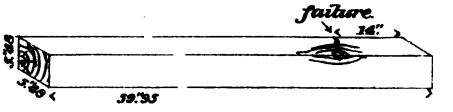
COMPRESSION TESTS OF WHITE-PINE POSTS.

No. 511.



Weight, 7 pounds.
Sectional area, 30.25 square inches.
Ultimate strength, 108,000 pounds = 3,570 pounds per square inch.
Fibers crushed at middle of block.

No. 491.

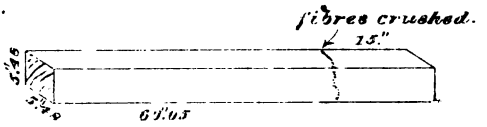


Weight, 26½ pounds.
Sectional area, 30 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,000	100	0.		
15,000	500	.0145		
3,000	100		.0005	
30,000	1,000	.0340		
3,000	100		.0	
45,000	1,500	.0540		
3,000	100		.0003	
60,000	2,000	.0738		
3,000	100		.0	
111,000	3,700			Ultimate strength.

Failed suddenly by the fibers crushing at a knot $1\frac{3}{4}''$ diameter $14''$ from end of post.

No. 492.

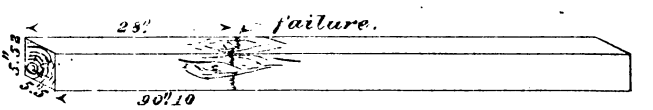


Weight, 31 pounds.
Sectional area, 30 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,000	100	0.		Post free from knots.
15,000	500	.0195		
3,000	100		0.	
30,000	1,000	.0450		
3,000	100		.0005	
45,000	1,500	.0708		
3,000	100		.0010	
60,000	2,000	.0962		
3,000	100		.0015	
99,300	3,310			Ultimate strength.

Failed suddenly by the fibers crushing 15″ from end of stick.

No. 493.

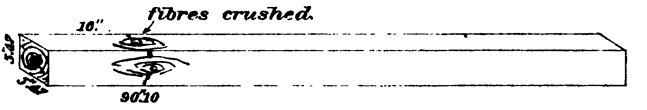


Weight, $43\frac{1}{2}$ pounds.
Sectional area, 30.4 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,040	100	0.	.....	This stick contains 12 knots from ¾" to 2½" diameter.
15,200	500	.0280	.....	
3,040	100	.....	.0010	
30,400	1,000	.0639	.....	
3,040	100	.....	.0020	
45,600	1,500	.1020	.....	
3,040	100	.....	.0035	
60,800	2,000	.1580	.....	
3,040	100	.....	.0122	
67,400	2,217	.....	.....	Ultimate strength.

Fibers crushed and longitudinal seams opened 28″ from end of stick, in the vicinity of several knots.

No. 494.

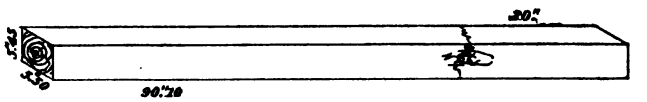


Weight, 37½ pounds.
Sectional area, 29.9 square inches.
Gauged length, 50″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,990	100	0.	.....	Stick contains eleven knots, 1″ diameter.
14,950	500	.0150	.....	
2,990	100	.....	0.	
29,900	1,000	.0340	.....	
2,990	100	.....	.0002	
44,850	1,500	.0535	.....	
2,990	100	.....	.0005	
59,800	2,000	.0748	.....	
2,990	100	.....	.0010	
70,800	2,368	.....	.....	Ultimate strength.

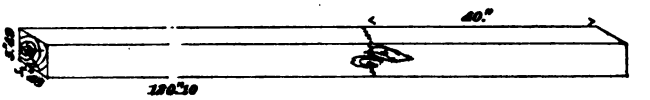
Failed at five knots 16″ from end.

No. 495.



Weight, 45 pounds.
Sectional area, 29.8 square inches.
Ultimate strength, 74,100 pounds = 2,487 pounds per square inch.
Failed from 20″ to 25″ from end where the stick was cross-grained and had some knots.

No. 512.

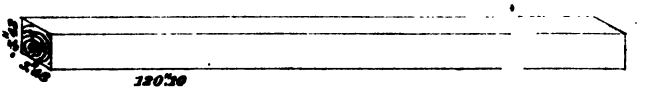


Weight, 62½ pounds.
Sectional area, 30.1 square inches.
Gauged length, 100″.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,010	100	0.	.....	0.	0.	
15,050	500	.0345	.....	.01	0.	
3,010	100	.....	0.	0.	0.	
30,100	1,000	.0775	.....	.03	— .05	
.....	100	.....	.0008	0.	0.	
45,150	1,500	.1206	.....	.07	— .08	
.....	100	.....	.0013	0.	0.	
60,200	2,000	.1655	.....	.10	— .10	
.....	100	.....	.0025	0.	— .01	
70,000	.....	.....	.....	.07	— .12	
80,000	.....	.....	.....	.17	— .18	
82,000	2,724	.....	.....	.....	.....	Ultimate strength.

Failed at some knots 40″ from end. Maximum deflection occurred at this point.

No. 519.

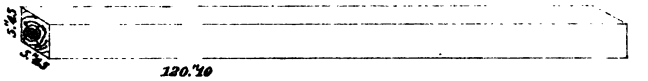


Sectional area, 29.7 square inches.
Gauged length, 100″.
Weight, 49½ pounds.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
2,970	100	0.	.....	0.	0.	
14,850	500	.0325	.....	0.	0.	
.....	100	.....	— .0006	0.	0.	
29,700	1,000	.0765	.....	0.	0.	
.....	100	.....	— .0004	0.	0.	
44,550	1,500	.1220	.....	0.	0.	
.....	100	.....	— .0004	0.	0.	
75,400	2,539	.....	.....	.....	.....	Ultimate strength.

Failed at some knots near middle of stick. Deflecting sideways.

No. 520.

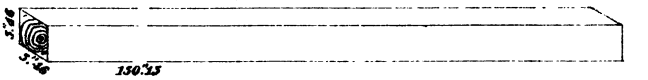


Sectional area, 29.7 square inches.
Gauged length, 100″.
Weight, 59½ pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
2, 970	100	0.	.....	0.	0.	
14, 850	500	. 0350	.....	0.	0.	
.....	100	.....	. 0005	0.	0.	
29, 700	1, 000	. 0770	.....	0.	. 04	
.....	100	.....	. 0007	0.	0.	
44, 550	1, 500	. 1210	.....	0.	. 08	
.....	100	.....	. 0015	0.	0.	
61, 700	2, 077	.....	.....	— . 06	. 15	Ultimate strength.

Failed at some knots 30″ from end.

No. 516.



Sectional area, 29.8 square inches.
Gauged length, 100″.
Weight, 60 pounds.
Counterweight at middle, 30 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
2, 980	100	0.	0.	0.	0.	
14, 900	500	. 0195	.....	— . 04	— . 01	
.....	100	.....	. 0010	0.	0.	
29, 800	1, 000	. 1015	.....	— . 10	— . 06	
.....	100	.....	. 0020	0.	. 0	
44, 700	1, 500	. 1602	.....	— . 15	— . 09	
.....	100	.....	. 0030	0.	— . 01	
59, 600	2, 000	.....	.....	— . 25	— . 12	
68, 000	2, 282	.....	.....	.....	.....	Ultimate strength.

Failed at a group of knots 64″ from end.

This post had groups of knots at intervals along its length of 18″ to 24″. The failure occurred at the third group from the end.

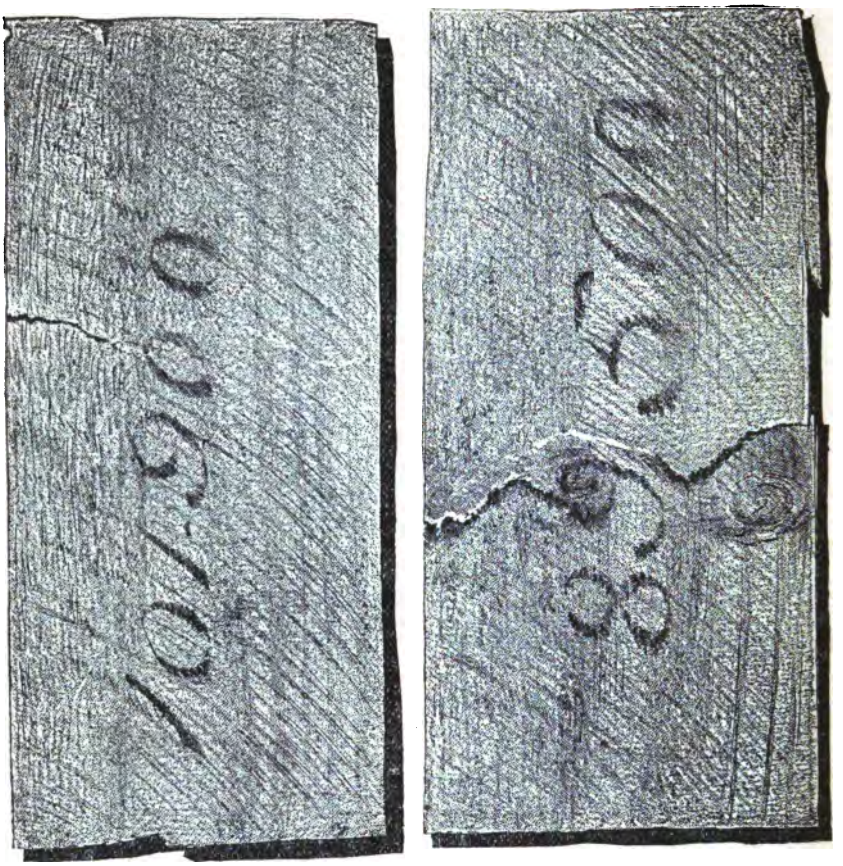
Post now sawed apart and a block (No. 516¹, 12″ long) obtained free from knots, also a block (No. 516², 12″ long) containing a group of knots. Their ultimate compression strength obtained as below.

Blocks tested seven days after original test.

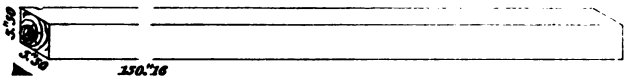
Block No. 516¹ (free from knots): Ultimate strength, 101,900 pounds = 3,420 pounds per square inch.

Block No. 516² (contains seven knots from ½″ to 1″ diameter): Ultimate strength, 89,500 pounds = 3,003 pounds per square inch.

BLOCK No. 516[1]. BLOCK No. 516[2].



No. 517.

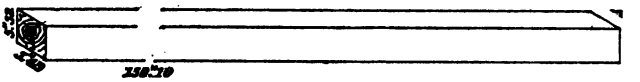


Sectional area, 30.25 square inches.
Weight, 70 pounds.
Counterweight at middle, 35 pounds.
Gauged length, 100″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,025	100	0.	0.	0.	0.	
15,125	500	.1340	.....	0.	0.	
.....	100	.....	0.	0.	0.	
30,250	1,000	.0760	.....	—.05	0.	
.....	100	.....	0.	0.	0.	
45,375	1,500	.1200	.....	—.10	0.	
.....	100	.....	.0005	0.	0.	
60,500	2,000	.....	.....	—.14	0.	
70,800	2,340	.....	.....	.....	.....	Ultimate strength.

Failed at a group of knots 58″ from end.

No. 518.

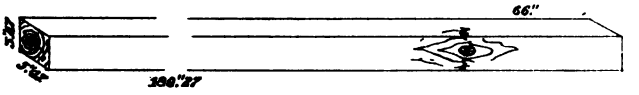


Sectional area, 30.25 square inches.
Weight, 67½ pounds.
Gauged length, 100″.
Counterweight at middle, 34 pounds.

Loads applied.	Pound s per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,025	100	0.	.....	0.	0.	
15,125	500	.0272	.....	0.	0.	
.....	100	.....	0.	0.	0.	
30,250	1,000	.0625	.....	0.	0.	
.....	100	.....	.0010	0.	0.	
45,375	1,500	.0980	.....	0.	.05	
.....	100	.....	.0010	0.	0.	
60,500	2,000	.....	.....	0.	.10	
100,000	3,306	.....	.....	0.	.12	Ultimate strength.

Failed at a group of knots 31″ from end.

No. 513.

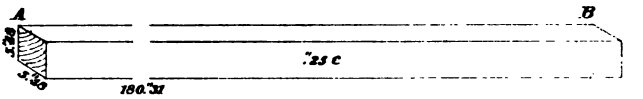


Sectional area, 29.9 square inches.
Gauged length, 100″.
Weight, 84½ pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
2,990	100	0.	0.	0.	0.	
14,950	500	.0300	.....	0.	0.	
.....	100	.....	.....	.....	.....	
29,900	1,000	.0675	.....	— .01	.10	
.....	100	.....	0.	0.	0.	
44,850	1,500	.0950	.....	— .06	.29	
.....	100	.....	— .0010	+ .04	— .04	
54,000	1,806	.....	.....	.....	.....	Ultimate strength.

Failed at a group of knots 66″ from end, deflecting sideways and upward.

No. 514.

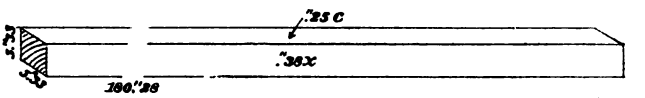


Sectional area, 30 square inches.
Gauged length, 100″.
Weight, 90 pounds.
Counterweight at middle, 45 pounds.
Initial bend before dressing down from size, 6″ × 6″: Horizontal, +″.25.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,000	200	0.	.....	0.	0.	
15,000	500	.0158	.....	0.	0.	
.....	200	.....	0.	0.	0.	
30,000	1,000	.0420	.....	0.	0.	
.....	200	.....	0.	0.	0.	
45,000	1,500	.....	.....	0.	0.	
60,000	2,000	.....	.....	0.	.05	
75,000	2,500	.....	.....	.02	.11	
90,000	3,000	.....	.....	.09	.28	
93,500	3,117	.....	.....	.....	.....	Ultimate strength.

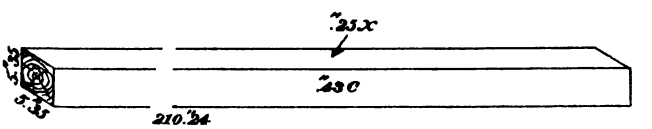
Failed by deflecting upward and sideways.
Fibers crushing at some knots 14″ from end *A*, and at some knots 24″ from end *B*.

No. 515.



Sectional area, 28.4 square inches.
Gauged length, 100″.
Weight, 91 pounds.
Counterweight at middle, 45 pounds.
Initial bend in post before dressing down from size 6″ × 6″: Horizontal, —″.38; vertical, —″.25.

No. 521.

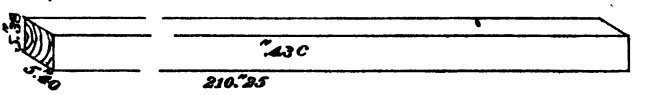


Sectional area, 28.6 square inches.
Weight, 96½ pounds.
Counterweight at middle, 48 pounds.
Initial bends in stick before dressing down from size 6″ × 6″: Horizontal, +″.43; vertical, +″.25.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	0.	— .13	
4,000	0.	— .13	
6,000	0.	— .11	
8,000	0.	— .10	
10,000	0.	— .10	
12,000	0.	— .10	
14,000	0.	— .10	
16,000	.02	— .10	
18,000	.03	— .09	
20,000	.04	— .08	
22,000	.05	— .07	
24,000	.07	— .07	
26,000	.09	— .07	
28,000	.10	— .07	
30,000	.11	— .06	
32,000	.12	— .06	
34,000	.14	— .05	
36,000	.16	— .05	
38,000	.18	— .05	
40,000	.20	— .05	
42,000	.24	— .05	
44,000	.28	— .05	
48,000	.44	— .07	
50,000	.55	— .10	
52,000	.90	— .20	
53,000	1.27	— .40	Ultimate strength =1,858 pounds per square inch.

Deflected sideways and downward.
Crushed fibers in vicinity of small knots ($\frac{1}{2}$″ diameter) at middle.

No. 522.

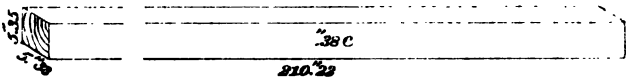


Sectional area, 29 square inches.
Weight, 101 pounds.
Counterweight at middle, 50 pounds.
Initial deflection in stick before dressing down from size 6″×6″: Horizontal, + ″.43.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	0.	— .15	
4,000	0.	— .15	
6,000	0.	— .16	
8,000	0.	— .16	
10,000	0.	— .17	
12,000	0.	— .17	
14,000	0.	— .17	
16,000	0.	— .18	
18,000	0.	— .19	
20,000	0.	— .20	
22,000	0.	— .21	
24,000	0.	— .24	
26,000	0.	— .26	
28,000	0.	— .29	
30,000	0.	— .32	
32,000	0.	— .38	
34,000	— .02	— .45	
36,000	— .03	— .52	
38,000	— .06	— .72	
40,000	— .14	—1.05	
40,500	— .14	—1.48	Ultimate strength = 1,396 pounds per square inch.

Deflected sideways and downward, opening seam (wind shake) on concave side.

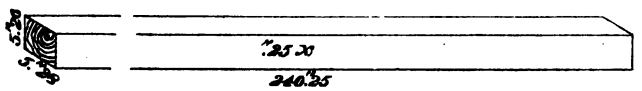
No. 523.



Sectional area, 28.5 square inches.
Weight, 95 pounds.
Counterweight at middle, 47 pounds.
Initial deflection before dressing down from size 6″ × ″6: Horizontal, + ″.38.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	+ .06	— .11	
4,000	.09	— .07	
6,000	.09	— .04	
8,000	.09	— .03	
10,000	.09	— .01	
12,000	.09	0.	
14,000	.09	0.	
16,000	.09	.01	
18,000	.10	.01	
20,000	.10	.01	
22,000	.11	.01	
24,000	.12	.01	
26,000	.13	.01	
28,000	.14	.01	
30,000	.15	.01	
34,000	.17	.01	
38,000	.20	.01	
42,000	.24	.01	
46,000	.29	0.	
50,000	.36	— .02	
54,000	.47	— .05	
60,000	.70	— .19	
64,000	1.19	— .50	
64,800	.....	.....	Ultimate strength = 2,274 pounds per square inch.

No. 524.

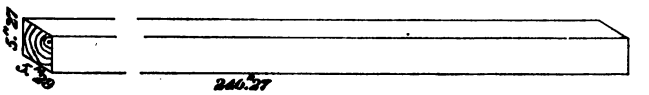


Sectional area, 27.8 square inches.
Weight, 109½ pounds.
Counterweight at middle, 55 pounds.
Initial deflection of stick before dressing down from original size 6″ × ″6: Horizontal, — ″.25.
Seven knots in post, from ¾″ to 1¼″ diameter.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	.0	.0	
4,000	—.04	.0	
6,000	—.06	—.02	
8,000	—.08	—.04	
10,000	—.10	—.06	
12,000	—.12	—.08	
14,000	—.14	—.10	
16,000	—.16	—.13	
18,000	—.18	—.16	
20,000	—.19	—.19	
22,000	—.21	—.22	
24,000	—.22	—.26	
26,000	—.25	—.29	
28,000	—.26	—.33	
30,000	—.29	—.38	
32,000	—.32	—.42	
34,000	—.35	—.50	
36,000	—.40	—.60	
38,000	—.44	—.68	
40,000	—.51	—.82	
42,000	—.62	1.04	
44,000	—.79	1.30	
45,000	1.30	1.20	Ultimate strength = 1,619 pounds per square inch.

Fibers crushed at knot near middle of post.

No. 525.

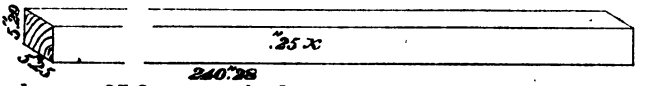


Sectional area, 27.9 square inches.
Weight, 106½ pounds.
Counterweight at middle, 53 pounds.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	.04	—.17	
4,000	.04	—.17	
6,000	.04	—.19	
8,000	.04	—.20	
10,000	.04	—.21	
12,000	.06	—.22	
14,000	.07	—.24	
16,000	.10	—.26	
18,000	.12	—.28	
20,000	.14	—.30	
22,000	.17	—.33	
24,000	.20	—.36	
24,000	.20	—.36	Sustained load 5 minutes.
26,000	.24	—.40	
28,000	.30	—.45	
30,000	.36	—.50	
32,000	.45	—.58	
34,000	.55	—.66	
36,000	.73	—.80	
38,000	.96	—1.00	
39,500	1.70	—1.60	Ultimate strength = 1,416 pounds per square inch.

Failed at two knots (¾″ × 1½″ diameter) at middle of post.

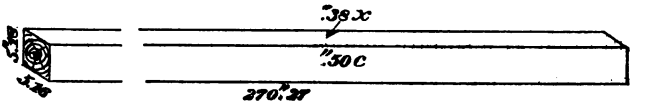
No. 526.



Sectional area, 27.8 square inches.
Weight, 95 pounds.
Counterweight at middle, 47 pounds.
Initial deflection in stick before dressing down from size 6″ × 6″: Horizontal, —″.25.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	—.05	0.	
4,000	—.05	0.	
6,000	—.05	0.	
8,000	—.04	0.	
10,000	—.03	0.	
12,000	—.03	.01	
14,000	—.03	.01	
16,000	—.02	.02	
18,000	—.01	.03	
20,000	0.	.04	
22,000	0.	.05	
24,000	0.	.05	
26,000	.01	.06	
28,000	.03	.07	
30,000	.05	.08	
32,000	.09	.10	
34,000	.14	.10	
36,000	.27	.10	
37,000	1.88	.80	Ultimate strength = 1,331 pounds per square inch.

No. 505.

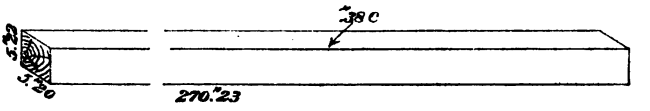


Weight, 110 pounds.
Counterweight at middle, 55 pounds.
Sectional area, 26.7 square inches.
Initial bends in post before dressing down from size 6″ × 6″: Horizontal + ″.50; vertical, + ″.38.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	.04	0.	
4,000	.04	.02	
6,000	.04	.06	
8,000	.04	.11	
10,000	.04	.13	
12,000	.04	.15	
14,000	+ .02	.16	
16,000	.0	.18	
18,000	— .01	.20	
20,000	— .02	.21	
22,000	— .05	.24	
24,000	— .08	.26	
26,000	— .11	.28	
28,000	— .15	.30	
30,000	— .22	.34	
32,000	— .33	.40	
34,000	— .50	.50	
36,000	— .90	.60	
37,000	—2.50	.90	Ultimate strength = 1,386 pounds per square inch.

Failed by deflecting sideways and upward. When deflection reached 3″ sideways, the post suddenly sprung, increasing the deflection to 8″.

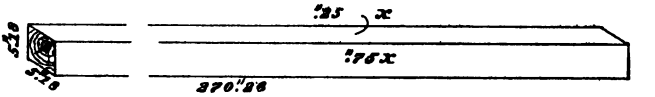
No. 506.



Weight, 113 pounds.
Counterweight at middle, 56 pounds.
Sectional area, 27.1 square inches.
Initial bend before dressing down from size 6″ × 6″: Vertical, —″.38.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	0.	0.	
4,000	— .02	— .02	
6,000	— .05	— .05	
8,000	— .08	— .05	
10,000	— .09	— .06	
12,000	— .11	— .09	
14,000	— .14	— .10	
16,000	— .16	— .11	
18,000	— .18	— .12	
20,000	— .21	— .14	
22,000	— .25	— .15	
24,000	— .30	— .17	
26,000	— .34	— .18	
28,000	— .40	— .20	
30,000	— .48	— .20	
32,000	— .58	— .21	
34,000	— .80	— .20	
35,000	—1.05	— .20	
36,000	—1.35	— .20	
37,000	—1.92	— .20	
37,200	.....	.....	Ultimate strength = 1,373 pounds per square inch.

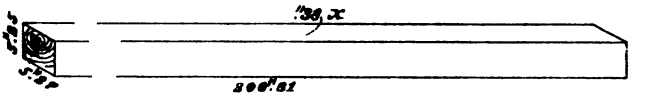
No. 507.



Weight, 118 pounds.
Counter weight at middle, 59 pounds.
Sectional area, 26.8 square inches.
Initial deflection before dressing down from size 6″ × 6″: Horizontal, —″.75; vertical, + ″.25.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	—.19	.05	
4,000	—.11	.08	
6,000	—.10	.10	
8,000	—.09	.12	
10,000	—.08	.13	
12,000	—.08	.14	
14,000	—.09	.15	
16,000	—.10	.16	
18,000	—.10	.18	
20,000	—.12	.19	
22,000	—.14	.20	
24,000	—.15	.21	
26,000	—.16	.24	
28,000	—.20	.25	
30,000	—.22	.26	
32,000	—.27	.30	
34,000	—.30	.32	
36,000	—.35	.35	
38,000	—.42	.40	
40,000	—.50	.43	
41,000	—.58	.50	
42,000	—.66	.51	
43,000	—.78	.55	
44,000	—.98	.60	
45,000	—1.21	.65	
46,000	—1.60	.70	
46,700	—2.40	.75	Ultimate strength = 1,743 pounds per square inch.

No. 502.

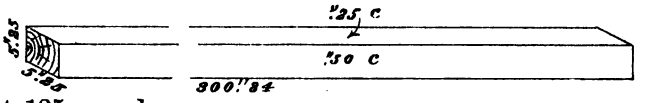


Weight, 127 pounds.
Counterweight at middle, 63 pounds.
Sectional area, 27.7 square inches.
Initial bend in stick before dressing down from size 6″ × 6″: Vertical, + ″.38.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	—.17	.32	
4,000	—.17	.35	
6,000	—.17	.38	
8,000	—.20	.40	
10,000	—.22	.42	
12,000	—.24	.46	
14,000	—.27	.50	
16,000	—.30	.52	
18,000	—.34	.58	
20,000	—.37	.64	
21,000	—.40	.70	
22,000	—.42	.75	
23,000	—.46	.80	
24,000	—.50	.86	
25,000	—.54	.95	
26,000	—.60	1.03	
27,000	—.65	1.20	
28,000	—.74	1.35	
29,000	—.87	1.60	
30,000	—1.08	1.98	
30,900	—1.48	2.70	Ultimate strength = 1,116 pounds per square inch.

Failed by deflecting upward and sideways.

No. 503.

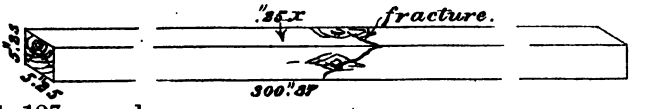


Weight, 125 pounds.
Counterweight at middle, 62 pounds.
Sectional area, 27.6 square inches.
Initial bend in post before dressing down from size 6″ × 6″: Horizontal, + ″.50; vertical, — ″.25.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	+ .56	— .30	
4,000	+ .56	— .26	
6,000	+ .56	— .25	
8,000	.58	— .24	
10,000	.62	— .25	
12,000	.69	— .26	
14,000	.75	— .27	
16,000	.84	— .29	
18,000	.95	— .31	
20,000	1.10	— .35	
21,000	1.19	— .37	
22,000	1.30	— .40	
23,000	1.40	— .45	
24,000	1.60	— .50	
25,000	1.85	— .60	
25,800	.....	.....	Ultimate strength = 935 pounds per square inch.

This post had two knots at middle about $1\frac{3}{4}$″ diameter each, and corners near middle chipped off $\frac{1}{2}$″ chamfer.
When post passed maximum load and deflected sideways and downward it splintered near middle, in the vicinity of the knots.

No. 504.

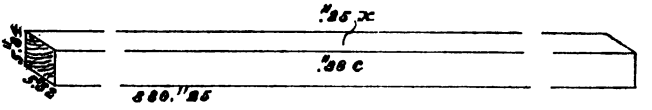


Weight, 127 pounds.
Counterweight at middle, 62 pounds.
Sectional area, 27.6 square inches.
Initial bend in post before dressing down from size 6″×6″: Vertical, +″.25.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
2,000	+ .35	— .23	
4,000	.36	— .22	
6,000	.37	— .19	
8,000	.39	— .16	
10,000	.41	— .12	
12,000	.45	— .06	
14,000	.50	+ .02	
16,000	.55	.14	
18,000	.63	.31	
20,000	.79	.64	
21,000	.93	.95	
22,000	1.24	1.60	
22,200	.....	.....	Ultimate strength = 804 pounds per square inch.

Failed by deflecting sideways and upward.
Sprung suddenly and fractured at some knots near middle.
Oblique fracture.

No. 496.

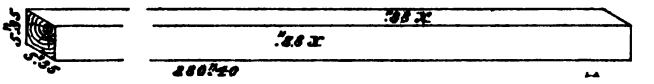


Weight, 169 pounds.
Counterweight at middle, 85 pounds.
Sectional area, 28.4 square inches.
Before dressing down from 6″×6″ stick, the post was deflected at middle: Horizontal, +″.38; vertical, +″.25, being convex on the heart side.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
1,000	0.	0.	
2,000	0.	0.	
3,000	.02	0.	
4,000	.02	0.	
5,000	.02	0.	
6,000	.03	0.	
7,000	.05	.02	
8,000	.06	.04	
9,000	.08	.05	
10,000	.09	.06	
11,000	.10	.08	
12,000	.11	.10	
13,000	.13	.11	
14,000	.14	.12	
15,000	.15	.14	
16,000	.17	.17	
17,000	.18	.20	
18,000	.20	.21	
19,000	.22	.24	
20,000	.25	.27	
19,000	.10	.11	
20,000	.25	.27	
21,000	.27	.30	
22,000	.30	.34	
23,000	.35	.38	
24,000	.40	.41	
25,000	.45	.47	
26,000	.50	.52	
27,000	.58	.58	
28,000	.68	.67	
29,000	.80	.77	
30,000	.99	.93	
31,000	1.20	1.12	
32,000	1.70	1.60	
32,500	.....	.....	Ultimate strength = 1,144 pounds per square inch.

Failed by deflection sideways and upward, taking a sudden spring immediately after the maximum load was reached.
The deflections followed the initial bend the stick had before dressing

No. 497.

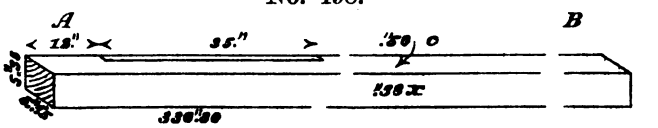


Weight, 173 pounds.
Counterweight at middle, 85 pounds.
Sectional area, 28.6 square inch.
Before dressing down from 6″×6″ stick, post had initial deflection: Horizontal, —″.38; vertical, +″.38.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
1,000	0.	0.	
2,000	0.	—.02	
3,000	0.	—.04	
4,000	0.	—.04	
5,000	0.	—.04	
6,000	0.	—.04	
7,000	0.	—.04	
8,000	—.02	—.04	
9,000	—.05	—.04	
10,000	—.06	—.03	
11,000	—.07	—.02	
12,000	—.08	—.01	
13,000	—.10	0.	
14,000	—.11	0.	
15,000	—.11	0.	
16,000	—.14	.01	
17,000	—.16	.03	
18,000	—.18	.04	
19,000	—.20	.05	
20,000	—.23	.07	
21,000	—.27	.09	
22,000	—.31	.11	
23,000	—.34	.14	
24,000	—.38	.16	
25,000	—.44	.18	
26,000	—.51	.22	
27,000	—.58	.28	
28,000	—.70	.32	
29,000	—.86	.40	
30,000	—1.06	.49	
31,000	—1.32	.56	
32,000	.....	.....	Ultimate strength = 1,119 pounds per square inch.

Failed by deflection sideways and upward, following the initial direction of the bends in the upward movement and contrary to the sideways initial bend.

No. 498.



Weight, 157 pounds.
Sectional area, 28.6 square inches.
Counter weight at middle, 78 pounds.
Initial bend in post before dressing down from 6″×6″ square: Horizontal, —″.38; vertical, —″.50. Piece 5″.35×″.70×″.35 set in end *A* 12″ from end of stick.

Loads applied.	Deflections.		Remarks.
	Horizontal.	Vertical.	
Pounds.	*Inch.*	*Inch.*	
1,000	0.	0.	
2,000	0.	0.	
3,000	0.	+ .01	
4,000	0.	.02	
5,000	0.	.04	
6,000	— .01	.05	
7,000	— .02	.07	
8,000	— .02	.08	
9,000	— .03	.09	
10,000	— .04	.10	
11,000	— .04	.11	
12,000	— .04	.12	
13,000	— .04	.14	
14,000	— .03	.15	
15,000	— .03	.16	
16,000	— .02	.18	
17,000	— .02	.20	
18,000	— .01	.21	
19,000	— .01	.22	
20,000	0.	.24	
21,000	0.	.26	
22,000	+ .01	.28	
23,000	.02	.31	
24,000	.04	.34	
25,000	.06	.38	
26,000	.12	.48	
27,000	.23	.65	
28,000	.67	1.25	Ultimate strength = 979 pounds per square inch.

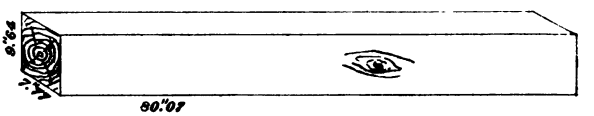
Failed by deflection sideways and upward, taking a contrary direction to the upward initial bend in the post but continuing the initial sideways bend.

The piece set in near end *A* did not appear to have caused weakness and given direction to final deflection, although it was on the concave side at final failure.

COMPRESSION OF WHITE-PINE POSTS—(Continued).

Specimens from stock 8″×10″, 6″×16″, 7″×16″, *and* 9″×17″.

No. 569.

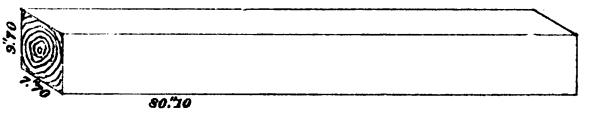


Sectional area, 74.9 square inches.
Gauged length, 50″.
Weight, 94 pounds.
Not counterweighted.
Average rate of growth, 10 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,490	100	0.		
37,450	500	.0129		
	100		0.	
74,900	1,000	.0311		
	100		—.0005	
112,350	1,500	.0505		
	100			
149,800	2,000	.0704		
	100		0.	
204,000	2,724			Ultimate strength.

Failed at knots 10″ from middle of post.

No. 570.

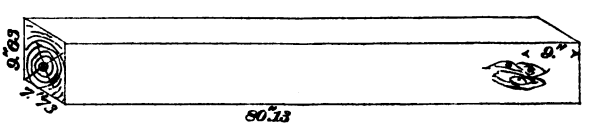


Sectional area, 74.7 square inches.
Gauged length, 50″.
Weight, 93 pounds.
Not counterweighted.
Average rate of growth, 7 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,470	100	0.		
37,350	500	.0150		
	100		—.0004	
74,700	1,000	.0360		
	100		—.0010	
112,050	1,500	.0580		
	100		—.0010	
149,400	2,000	.0810		
	100		.0004	
177,000	2,369			Ultimate strength.

Failed at some knots near middle of post.

No. 571.

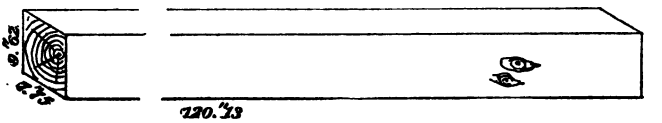


Sectional area, 74.4 square inches.
Gauged length, 50″.
Weight, 120½ pounds.
Post contains considerable sap.
Not counterweighted.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,440	100	0.		
37,200	500	.0120		
	100		0.	
74,400	1,000	.0314		
	100		0.	
111,600	1,500	.0522		
	100		— .0002	
148,800	2,000	.0730		
	100		0.	
185,000	2,487			Ultimate strength.

Failed at a group of knots 9″ from end of post.

No. 575.

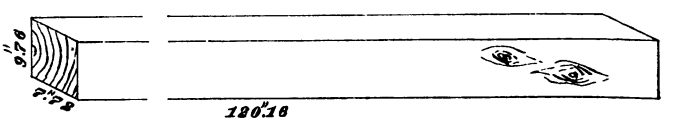


Sectional area, 74.6 square inches.
Gauged length, 100″.
Weight, 166 pounds.
Not counterweighted.
Average rate of growth, 15 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,460	100	0.		
37,300	500	.0302		
	100		0.	
74,600	1,000	.0695		
	100		0.	
111,900	1,500	.1110		
	100		0.	
149,200	2,000	.1537		
	100		.0010	
186,000	2,493			Ultimate strength.

Failed at some knots 21″ from end of post.

No. 576.

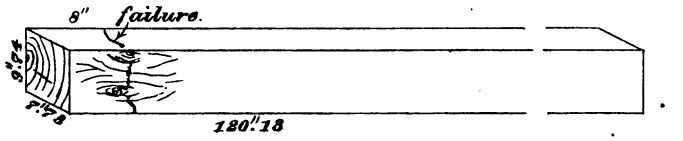


Sectional area, 75.3 square inches.
Gauged length, 100″.
Weight, 166 pounds.
Not counterweighted.
Average rate of growth, 11 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,530	100	0.		
37,650	500	.0276		
	100		0.	
75,300	1,000	.0625		
	100		.0008	
112,950	1,500	.0988		
	100		.0018	
150,600	2,000	.1379		
	100		.0031	
204,600	2,717			Ultimate strength.

Failed in the vicinity of knots 13″ and 27″ from end of post.

No. 577.

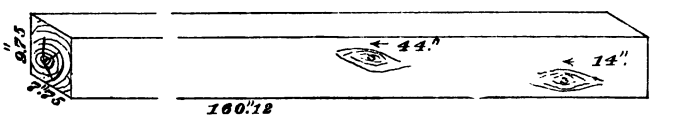


Sectional area, 75.3 square inches.
Gauged length, 100″.
Weight, 160 pounds.
Not counterweighted.
Average rate of growth, 10 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,530	100	0.		
37,650	500	.0268		
	100		0.	
75,300	1,000	.0657		
	100			
112,950	1,500	.1070		
	100		.0005	
135,000	1,793			Ultimate strength.

Failed at knots 8″ to 11″ from end.

No. 581.

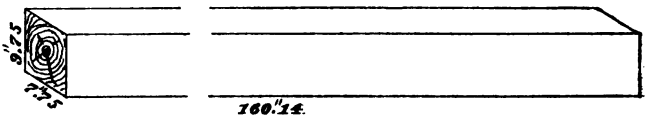


Sectional area, 75.6 square inches.
Gauged length, 100″.
Weight, 221 pounds.
Not counterweighted.
Average rate of growth, 7 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,560	100	0.		
37,800	500	.0312		
	100		—.0005	
75,600	1,000	.0750		
	100		—.0005	
113,400	1,500	.1210		
	100		—.0004	
151,200	2,000	.1718		
	100		.0014	
168,000	2,222			Ultimate strength.

Failed at knots 14″ and 44″ from end.

No. 582.

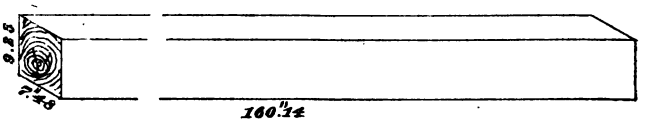


Sectional area, 75.6 square inches.
Gauged length, 100″.
Weight, 182 pounds.
Not counterweighted.
Average rate of growth, 3 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,560	100	0.		
37,800	500	.0510		
	100		.0010	
75,600	1,000	.1167		
	100		.0015	
113,400	1,500	.1880		
	100		.0046	
127,500	1,687			Ultimate strength.

Failed at knots 1¼″ diameter, 13″ and 18″ from end.

No. 583.

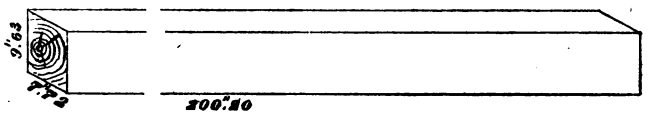


Sectional area, 69 square inches.
Gauged length, 100″.
Weight, 196½ pounds.
Not counterweighted.
Average rate of growth, 13 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
6,900	100			
34,500	500	.0298		
	100		.0010	
69,000	1,000	.0625		
	100		.0010	
103,500	1,500	.0950		
	100		.0020	
208,500	3,022			Ultimate strength.

Failed at a group of knots 50″ from end; largest knot, $1\frac{1}{8}$″ diameter.

No. 590.

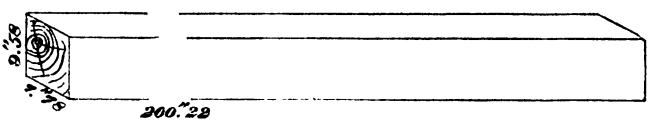


Sectional area, 74.3 square inches.
Gauged length, 150″.
Weight, 242 pounds.
Counterweight at middle, 126 pounds.
Average rate of growth, 7 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,430	100	0.		0.	0.	
37,150	500	.0446		.01	.03	
	100		0.	0.	0.	
74,300	1,000	.1060		.03	.05	
	100		0.	0.	0.	
111,450	1,500	.1710		.06	.06	
	100		.0010	.01	.01	
148,600	2,000	.2450		.10	.05	
	100		.0040	.01	0.	
161,000	2,167			.28	— .05	Ultimate strength.

Failed at knots 20″ from end. Five knots at place of failure, size varying from 1″ to $1\frac{1}{2}$″ diameter.

No. 591.

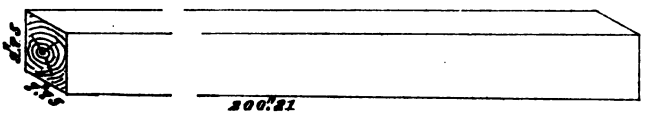


Sectional area, 74.5 square inches.
Gauged length, 150″.
Weight, $210\frac{1}{2}$ pounds.
Counterweight at middle, 108 pounds.
Average rate of growth, 9 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,450	100	0.		0.	0.	
37,250	500	.0565		0.	— .01	
	100		.0015	0.	0.	
74,500	1,000	.1275		0.	— .02	
	100		.0020	0.	0.	
111,750	1,500	.2008		— .01	— .04	
	100		.0030	0.	— .0	
149,000	2,000	.2850		.06	0.	
	100		.0094	0.	0.	
163,000	2,188			.35	— .30	Ultimate strength.

Failed at a group of knots near middle of post; one knot 2″ diameter.

No. 592.

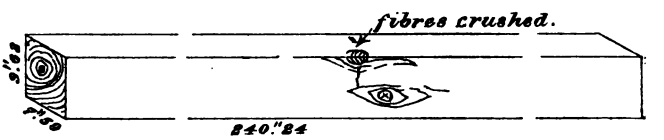


Sectional area, 75.6 square inches.
Gauged length, 150″.
Weight, 274 pounds.
Counter weight at middle, 138 pounds.
Average rate of growth, 8 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,560	100	0.		0.	0.	This post contained 23 knots, averaging 2″ diameter.
37,800	500	.0510		0.	— .04	
	100		.0012	0.	0.	
75,600	1,000	.1123		0.	— .07	
	100		.0023	0.	0.	
113,400	1,500	.1760		0.	— .10	
	100		.0037	0.	0.	
151,200	2,000	.2476		.03	— .14	
	100		.0088	0.	0.	
175,800	2,319			.10	— .21	Ultimate strength.

Failed 75″ from end, at a knot 2¼″ diameter.

No. 533.

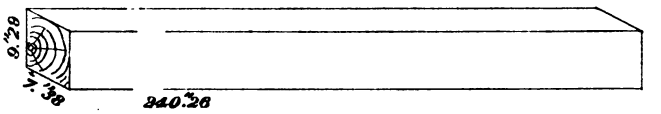


Sectional area, 73 square inches.
Gauged length, 200″.
Weight, 278 pounds.
Counterweight at middle, 138 pounds.
Post contains 30 knots, from ½″ to 1½″ diameter.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,300	100	0.	.....	0.	0.	
36,500	500	.0693	.....	−.02	−.03	
.....	100	.....	.0003	0.	0.	
73,000	1,000	.1570	.....	−.05	−.06	
.....	100	.....	.0010	0.	0.	
109,500	1,500	.2470	.....	−.08	−.10	
.....	100	.....	.0030	0.	−.01	
140,000	1,918	.....	.....	−1.20	−.49	Ultimate strength.

Deflected sideways. Fibers crushed at some knots at middle of post.

No. 534.

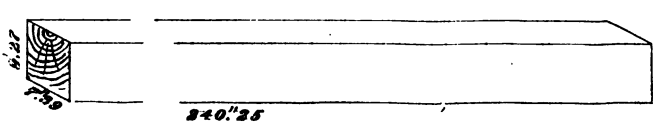


Sectional area, 68.6 square inches.
Gauged length, 200″.
Weight, 285 pounds.
Counterweight at middle, 138 pounds.
Quality of post as regards knots about the same as No. 533.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,860	100	0.	.....	0.	0.	
34,300	500	.0580	.....	.01	.07	
.....	100	.....	0.	0.	0.	
68,600	1,000	.1336	.....	0.	.15	
.....	100	.....	0.	0.	.01	
80,000	.....	.....	.....	−.01	.18	
90,000	.....	.....	.....	−.02	.20	
100,000	.....	.....	.....	−.03	.21	
110,000	.....	.....	.....	−.05	.24	
120,000	.....	.....	.....	−.07	.26	
130,000	.....	.....	.....	−.10	.29	
140,000	.....	.....	.....	−.15	.30	
150,000	.....	.....	.....	−.21	.32	
160,000	.....	.....	.....	−.35	.34	
166,000	2,420	.....	.....	−.70	.34	Ultimate strength.

Fibers crushed at knot near middle of post.

No. 535.



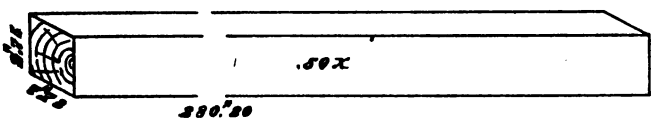
Sectional area, 68.5 square inches.
Gauged length, 200″.

Weight, 295 pounds.
Counterweight at middle, 138 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,850	100	0.	.....	0.	0.	
34,250	500	.0468	.....	0.	.02	
.....	100	.....	0.	0.	0.	
68,500	1,000	.1090	.....	0.	.04	
.....	100	.....	0.	0.	0.	
102,750	1,500	.1738	.....	−.01	.04	
.....	100	.....	0.	0.	0.	
110,000	.....	.....	.....	−.03	.03	
120,000	.....	.....	.....	−.04	.04	
130,000	.....	.....	.....	−.04	.04	
140,000	.....	.....	.....	−.05	.04	
150,000	.....	.....	.....	−.06	.04	
160,000	.....	.....	.....	−.08	.04	
170,000	.....	.....	.....	−.08	.03	
180,000	.....	.....	.....	−.09	.03	
190,000	.....	.....	.....	−.10	.02	
200,000	.....	.....	.....	−.10	.01	
206,000	3,007	.....	.....	+.10	−.04	Ultimate strength.

Failed at some knots 24″ from middle of post; maximum deflection at this point.

No. 539.

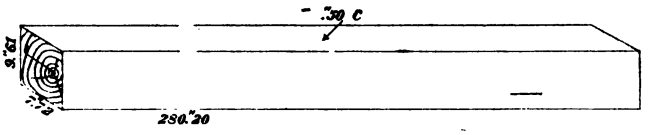


Sectional area, 75.4 square inches.
Gauged length, 200″.
Weight, 352 pounds.
Counterweight at middle, 176 pounds.
Initial bend in post before dressing down from size 8″×10″: Horizontal —″.50.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,540	100	0.	.....	0.	0.	
37,700	500	.0760	.....	−.04	.03	
.....	100	.....	.0006	0.	0.	
75,400	1,000	.1710	.....	−.08	.10	
.....	100	.....	.0010	0.	0.	
113,100	1,500	.2700	.....	−.21	.15	
.....	100	.....	.0025	0.	0.	
120,000	.....	.....	.....	−.26	.19	
130,000	.....	.....	.....	−.38	.20	
140,000	1,857	.....	.....	−.66	.22	Ultimate strength.

Sustained maximum load 3 minutes, horizontal deflection increasing rapidly.

No. 540.

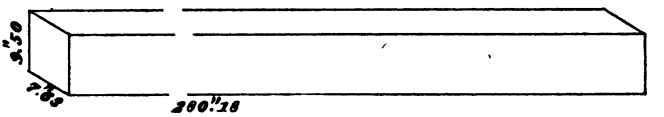


Sectional area, 74.2 square inches.
Gauged length, 200″.
Weight, 357 pounds.
Counterweight at middle, 178 pounds.
Initial deflection before dressing down from size 8″×10″: Vertical —″50.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,420	100	0.		0.	0.	Post contains 32 knots, varying in diameter from ¾″ to 1¼″.
37,100	500	.0556		.03	— .02	
	100		.0010	0.	0.	
74,200	1,000	.1240		.09	— .03	
	100		.0015	0.	0.	
111,300	1,500	.1960		.17	— .03	
	100		.0020	0.	0.	
120,000				.17	— .03	
130,000				.20	— .03	
140,000				.25	— .04	
150,000				.33	— .03	
160,000				.44	— .02	
170,000	2,291			.86	+ .04	Ultimate strength.

Failed by horizontal deflection, fibers crushing at knots near the middle.

No. 541.

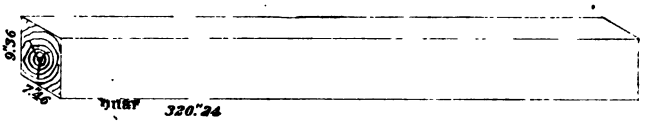


Sectional area, 72.5 square inches.
Gauged length, 200″.
Weight, 340 pounds.
Counterweight at middle, 170 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,250	100	0.		0.	0.	
36,250	500	.0580		0.	0.	
	100		.0014	0.	0.	
72,500	1,000	.1360		— .10	0.	
	100		.0020	0.	0.	
108,750	1,500	.2140		— .25	.04	
	100		.0030	— .02	0.	
120,000				— .32	.05	
130,000				— .41	.10	
140,000				— .61	.15	
150,000	2,069			—1.22	.40	Ultimate strength.

Failed by deflecting diagonally sideways and upward.

No. 536.

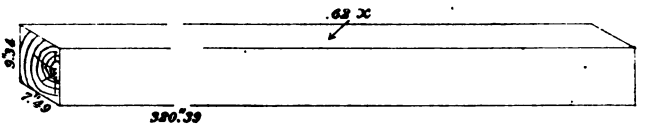


Sectional area, 69.8 square inches.
Gauged length, 300″.
Weight, 427 pounds.
Counterweight at middle, 214 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,980	100	0.	.....	0.	0.	
34,900	500	.0745	.....	0.	.03	
.....	100	.....	0.	0.	0.	
69,800	1,000	.1992	.....	0.	.08	
.....	100	.....	.0005	0.	0.	
104,700	1,500	.2705	.....	.03	.11	
.....	100	.....	.0017	0.	0.	
110,000	.....	.....	.....	.01	.13	
120,000	.....	.....	.....	.01	.15	
130,000	.....	.....	.....	.03	.16	
140,000	.....	.....	.....	.06	.19	
150,000	.....	.....	.....	.10	.21	
160,000	.....	.....	.....	.20	.23	
169,000	2,421	.....	.....	1.00	.15	Ultimate strength.

Failed by deflection sideways, crushing fibers at two places near middle of post at knots.

No. 537.

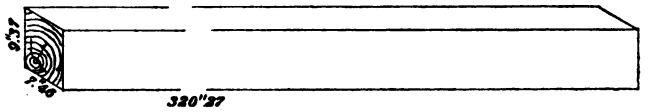


Sectional area, 70 square inches.
Gauged length, 300″.
Weight, 397 pounds.
Counterweight at middle, 200 pounds.
Initial bend in post before dressing down from size 8″×10″: Vertical, +″.62.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,000	100	0.	.....	0.	0.	
35,000	500	.0930	.....	—.02	—.07	
.....	100	.....	.0024	0.	0.	
70,000	1,000	.2025	.....	—.10	—.09	
.....	100	.....	.0030	—.01	0.	
105,000	1,500	.3144	.....	—.22	—.10	
.....	100	.....	.0044	—.02	0.	
110,000	.....	.....	.....	—.27	—.10	
120,000	.....	.....	.....	—.34	—.10	
130,000	.....	.....	.....	—.46	—.10	
140,000	2,000	.....	.....	—.70	—.10	Ultimate strength.

Deflected sideways, taking a sharp bend at middle at some knots.

No. 538.

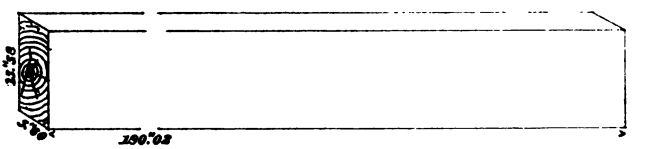


Sectional area, 69.9 square inches.
Gauged length, 300″.
Weight, 384 pounds.
Counterweight at middle, 200 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,990	100	0.	.....	0.	0.	
34,950	500	.0942	.....	0.	—.04	
.....	100	.....	.0017	0.	0.	
69,900	1,000	.2150	.....	.03	—.12	
.....	100	.....	—.0042	0.	0.	
104,850	1,500	.3444	.....	.15	—.22	
.....	100	.....	.0095	0.	—.01	
110,000	.....	.....	.....	.18	—.25	
120,000	.....	.....	.....	.30	—.30	
130,000	.....	.....	.....	.72	—.42	
134,000	1,917	.....	.....	1.67	—.60	Ultimate strength.

Deflected sideways and downward, crushing the fibers on concave side at knots.

No. 702.



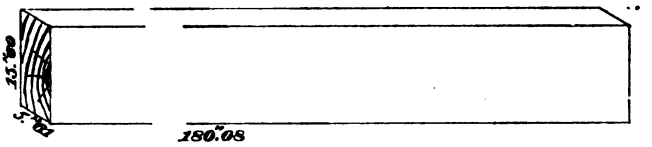
Sectional area, 87.2 square inches.
Gauged length, 150″.
Weight, 300 pounds.
Average weight of growth, 10 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*		
0	0	0.		0.	0.	0.	
43,600	500	.0700	0.	.01	—.03	.....	
.....	0	.....	.....	.....	.....	.....	
60,000	.....	.....	.0005	.01	—.03	.....	
80,000	.....	.....	.....	0.	—.04	.....	
100,000	.....	.....	.....	0.	—.04	.01	
120,000	.....	.....	.....	—.02	—.04	.....	
140,000	.....	.....	.....	—.10	—.05	.....	
150,000	.....	.....	.....	—.20	—.06	.10	
159,000	1,823	.....	.....	—.37	—.10	.....	Ultimate strength.

NOTE.—The letters W and E are used to indicate that vertical deflections were taken on the west and east side of machine. The measurements show an apparent vertical movement, plus on one side and minus on the other, as the stick twisted during the test.

Fibers crushed 23″ from end at a group of knots.

No. 703.

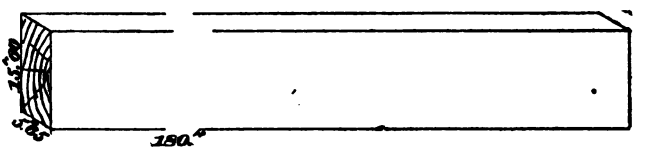


Sectional area, 87.5 square inches.
Gauged length, 150″.
Weight, 267 pounds.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
43,750	500	.0700	.....	.07	.06	— .05	
.....	0	.....	.0007	.....	.....	.....	
60,000	.....	.....	.....	.04	.07	.....	
80,000	.....	.....	.....	.02	.09	.....	
100,000	.....	.....	.....	0.	.10	0.	
120,000	.....	.....	.....	— .03	.10	.....	
140,000	.....	.....	.....	— .08	.10	.....	
155,000	.....	.....	.....	— .15	.10	.....	
160,000	.....	.....	.....	— .20	.10	.....	
168,500	1,926	.....	.....	— .51	.12	.....	Ultimate strength.

Failed by horizontal deflection, minus direction; took maximum deflection at a group of knots about 12″ from middle of stick.

No. 704.

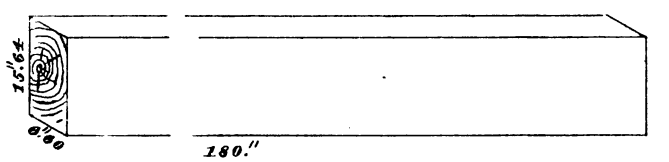


Sectional area, 88.1 square inches.
Gauged length, 150″.
Weight, 267 pounds.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
44,050	500	.0653	.....	0.	0.	0.	
.....	0	.....	.0003	.....	.....	.....	
60,000	.....	.....	.....	— .01	0.	.....	
80,000	.....	.....	.....	— .07	— .01	.....	
100,000	.....	.....	.....	— .11	— .02	.....	
120,000	.....	.....	.....	— .20	— .03	.....	
140,000	.....	.....	.....	— .31	— .03	.....	
150,000	.....	.....	.....	— .40	— .05	0.	
160,000	.....	.....	.....	— .55	— .06	.....	
165,000	1,873	.....	.....	— .83	— .10	.....	Ultimate strength.

Failed by horizontal deflection, minus direction; fibers crushed about 12″ from south end at a group of knots.

No. 699.

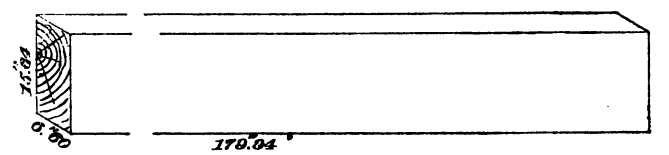


Sectional area, 103.2 square inches.
Weight, 356 pounds.
Gauged length, 150″.
Average rate of growth, 7 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	0.	0.	0.	
51,600	500	.0435	.....	0.	.05	.02	
0	0	.....	0.	.....	.....	.....	
80,000	.....	.....	.....	.01	.06	.....	
100,000	.....	.....	.....	.01	.07	.02	
120,000	.....	.....	.....	.02	.08	.....	
140,000	.....	.....	.....	.02	.09	.....	
160,000	.....	.....	.....	.02	.10	.....	
180,000	.....	.....	.....	.02	.10	.....	
200,000	.....	.....	.....	.02	.10	0.	
220,000	.....	.....	.....	.02	.11	.....	
230,000	.....	.....	.....	.02	.11	.....	
240,000	2,326	.....	.....	.03	.11	.....	Ultimate strength.

Failed by crushing fibres at a group of knots 40″ from end.

No. 700.

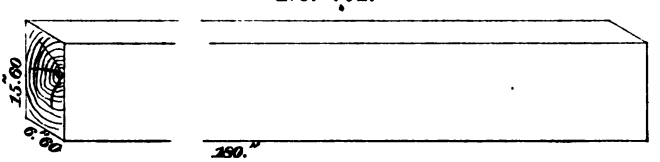


Sectional area, 103.2 square inches.
Gauged length, 150″.
Weight, 395 pounds.
Average rate of growth, 10 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
51,600	500	.0475		.05	.06	0.	
	0	.0	.0				
80,000				.08	.07		
100,000				.09	.08	— .02	
120,000				.11	.09		
140,000				.12	.10		
160,000				.15	.12		
180,000				.18	.13		
200,000				.21	.16	— .15	
220,000				.26	.20		
230,000				.31	.21	— .20	
239,000	2,316			.40	.28		Ultimate strength.

Stick failed at knots 10″ and 60″ from north end; opened oblique longitudinal crack between the above groups of knots.

No. 701.

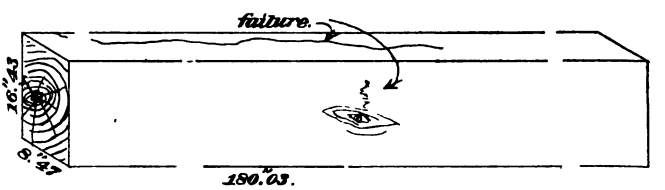


Sectional area, 103 square inches.
Gauged length, 150″.
Weight, 376 pounds.
Average rate of growth, 7 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
51,500	500	.0519		.03	.04	.02	
	0		.0				
80,000				.03	.05		
100,000				.03	.05		
120,000				.02	.05		
140,000				.02	.06		
160,000				.02	.06		
180,000				.02	.06		
200,000				.05	.05		
203,000	1,971						Ultimate strength.

Failed at a group of knots 15″ from middle of post.

No. 705.



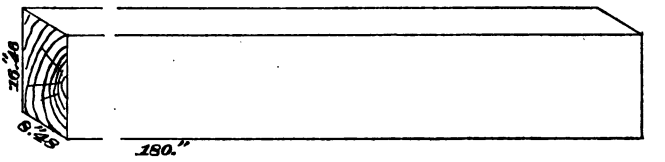
Sectional area, 139.2 square inches.
Gauged length, 150″.

Weight, 657 pounds.
Average rate of growth, 6 rings per inch.
Stick in wet condition.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
69,600	500	.0508	.....	−.10	.02	.....	
.....	0	.....	.0005	.....	.....	.....	
80,000	.....	.....	.....	−.10	.03	.....	
100,000	.....	.....	.....	−.10	.03	.02	
140,000	.....	.....	.....	−.10	.05	.....	
180,000	.....	.....	.....	−.10	.06	.....	
200,000	.....	.....	.....	−.11	.05	.....	
220,000	.....	.....	.....	−.13	.05	.....	
230,000	.....	.....	.....	−.15	.04	.....	
240,000	.....	.....	.....	−.16	.03	.....	
250,000	.....	.....	.....	−.19	.02	.....	
260,000	.....	.....	.....	−.20	.02	.....	
270,000	.....	.....	.....	−.25	−.02	.10	
279,400	2,007	.....	.....	−.35	−.09	.....	Ultimate strength.

Failed by crushing fibers in vicinity of knot at middle of stick; also, opened oblique longitudinal crack.

No. 706.

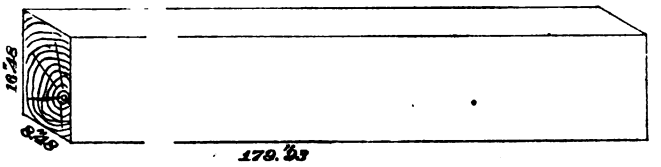


Sectional area, 139.6 square inches.
Ganged length, 150″.
Weight, 437 pounds.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
69,800	500	.0590	.....	.02	.08	−.05	
.....	0	.....	0.	.....	.....	.....	
100,000	.....	.....	.....	.03	.10	.....	
140,000	.....	.....	.....	.03	.13	.....	
180,000	.....	.....	.....	.03	.19	.....	
200,000	.....	.....	.....	.03	.20	−.10	
220,000	.....	.....	.....	.03	.22	.....	
240,000	.....	.....	.....	.03	.25	.....	
260,000	.....	.....	.....	.03	.30	−.15	
280,000	.....	.....	.....	0.	.37	.....	
292,000	2,092	.....	.....	−.10	.45	.....	Ultimate strength.

Failed at a group of knots at middle of stick, and at knots 29″ from north end.

No. 707.



Sectional area, 139.8 inches.
Gauged length, 150″.
Weight, 447 pounds.
Average rate of growth, 5 rings per inch.

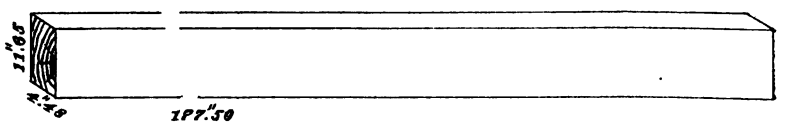
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0		0.	0.	0.	0.	
69,900	500	.0305		−.06	.10	.05	
	0		−.0005				
100,000				−.07	.11		
140,000				−.08	.13		
180,000				−.09	.16		
200,000				−.10	.18	.05	
220,000				−.10	.19		
240,000				−.10	.20		
260,000				−.10	.21		
280,000				−.12	.25		
290,000				−.13	.26		
300,000				−.13	.27		
320,000				−.15	.30		
340,000				−.18	.32		
350,000				−.22	.40	−.15	
359,000	2,568						Ultimate strength.

Failed by horizontal deflection, minus direction. Fibers crushed at north end, where the wood was imperfect, giving direction to the final deflection.

COMPRESSION TESTS OF WHITE PINE—(Continued.)

Single sticks and built posts.

No. 664.



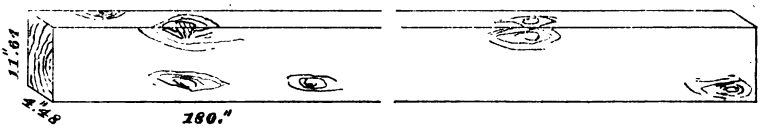
Sectional area, 52.2 square inches.
Gauged length, 150″.
Weight, 153 pounds.
Average rate of growth, 11 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	— .23	0.	0.	
26,100	500	.0545	.....	0.	.02	.....	
0	0	.....	.0004	— .21	0.	.....	
40,000	.....	.....	.....	+ .02	.04	— .06	
60,000	.....	.....	.....	0.	.07	.....	
80,000	.....	.....	.....	— .06	.07	.....	
100,000	.....	.....	.....	— .20	.07	— .08	
110,000	2,107	.....	.....	— .43	.10	.....	Ultimate strength.

Failed by horizontal deflection in minus direction.

Deflection increased to —2″.30 fibers of stick, crushing 15″ from middle, 2″ from north end, and 8″ from south end, in the vicinity of knots.

No. 665.



Sectional area, 52.1 square inches.

Weight, 143 pounds.

Gauged length, 150″.

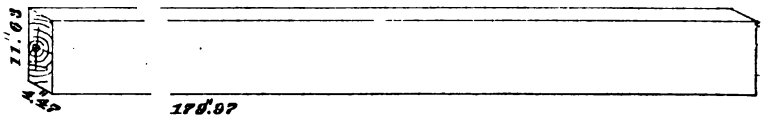
Average rate of growth, 10 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	— .07	0.	0.	
26,050	500	.1010	.....	+ .02	.....	.....	
0	0	.....	.0010	— .07	.....	.....	
30,000	.....	.....	.....	+ .02	— .09	— .06	
40,000	.....	.....	.....	+ .02	— .09	.....	
50,000	.....	.....	.....	.04	— .09	.....	
60,000	.....	.....	.....	.10	— .09	.....	
70,000	.....	.....	.....	.15	— .08	.....	
80,000	.....	.....	.....	.40	— .06	.....	
81,500	1,564	.....	.....	1.15	.....	.....	Ultimate strength.

Failed by horizontal deflection, plus direction.

Sprung sideways suddenly after passing the maximum load. Rotating around vertical edges of ends similar to a post with pin ends. Fibers not crushed.

No. 666.

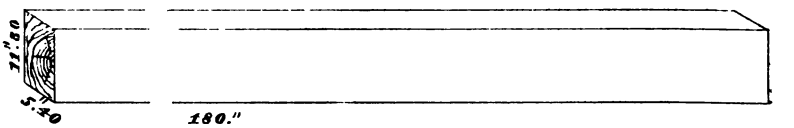


Sectional area, 52 square inches.
Gauged length, 150″.
Weight, 163 pounds.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
26,000	500	.0895		.07	— .10	0.	
0	0		.0004				
30,000				.09	— .10		
40,000				.11	— .12		
50,000				.16	— .13		
60,000				.28	— .13		
70,000	1,346			1.25			Ultimate strength.

Failed by horizontal deflection, plus direction.
When the horizontal deflection reached 3″ the post sprung suddenly sideways, rotating around vertical edges of ends.

No. 667.

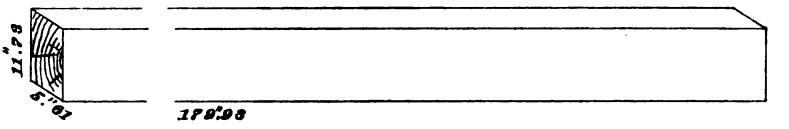


Sectional area, 61 square inches.
Gauged length, 150″.
Weight, 228 pounds.
Average rate of growth, 13 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.					
30,500	500	.0505		— .03	.04	— .04	
0	0		0.				
50,000				— .05	.08		
60,000				— .07	.09		
70,000				— .08	.10	— .10	
80,000				— .09	.10		
90,000				— .10	+ .11		
100,000				— .13	.12	— .15	
110,000				— .15	.15		
120,000				— .19	.16		
130,000				— .22	.17		
140,000				— .30	.18		
150,000				— .37	.20	— .22	
160,000	2,623			— .60	.20		Ultimate strength.

Failed by horizontal deflection, minus direction.
Loads continued gradually increasing the deflection to 3″, fibers of the stick crushing at the middle and 3½″ to 4½″ from ends.

No. 668.

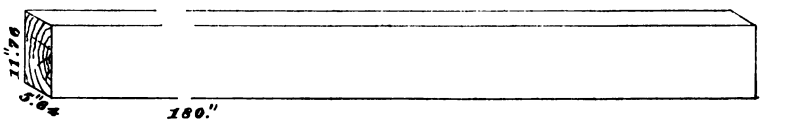


Sectional area, 65.8 square inches.
Gauged length, 150″.
Weight, 193 pounds.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
32,900	500	.0622		— .05	— .03		
	0		.0004				
50,000				— .08	— .04		
70,000				— .10	— .05		
90,000				— .14	— .05		
100,000				— .16	— .06	.09	
110,000				— .19	— .07		
120,000				— .21	— .07		
130,000				— .26	— .09		
140,000				— .32	— .10		
150,000				— .40	— .10	.18	
156,300	2,375			— .60	— .15		Ultimate strength.

Failed by horizontal deflection, minus direction.
Deflections increased to 3″. Fibers crushed at a group of knots 30″ from middle, where maximum deflection occurred. Fibers also crushed at some knots 3″ to 6″ from north end.

No. 669.

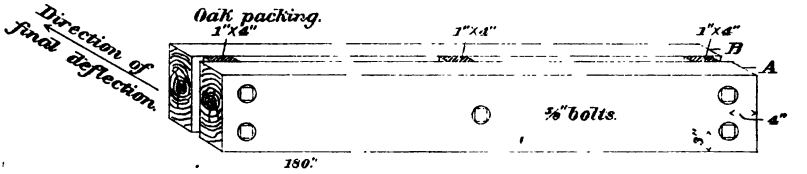


Sectional area, 66.3 square inches.
Gauged length, 150″.
Weight, 253 pounds.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0		0.	0.	0.	
33,150	500	.0608		0.	— .01		
	0		0004				
50,000					— .02	.02	
70,000				.01	— .05		
90,000				.04	— .07	.03	
100,000				.05	— .08		
110,000				.07	— .09		
120,000				.10	— .10		
130,000				.13	— .10		
140,000				.18	— .10		
150,000				.34	— .10	.01	
152,300	2,297			.60			Ultimate strength.

Failed by horizontal deflection, plus direction.
Fibers crushed at middle, in the vicinity of some knots.

No. 638.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	181	6	180	4.50	11.60	52.2	150
B	134	8	180	4.50	11.59	52.2	150
	315	.....	.....	.....	.....	104.4	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.
	Actual.	Pounds per sq. inch.			
	Pounds.		*Inch.*	*Inch.*	*Inch.*
A	26,100	500	.0670	(?)	+ .02
B	26,100	500	.0750	.0002	— .06

Test of built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	— .01	.02	.....	
60,000	— .01	.02	.....	
80,000	— .02	.02	.....	
100,000	— .03	.02	.....	
120,000	— .03	.02	.....	
140,000	— .04	.02	.....	
160,000	— .05	0.	.....	
180,000	— .05	0.	.....	
200,000	0.	—.01	.....	Ultimate strength = 1,916 pounds per square inch.

Failed by deflecting horizontally in plus direction. Post changed its direction of bending horizontally at 180,000 pounds.

When the load reached 200,000 pounds, measurement showed zero horizontal deflection. It now took a plus direction, which was increased to +1″.50, when the loads were released.

Under the maximum deflection, fibers of stick B crushed at some knots 15″ from middle.

No. 639.

Same style of post as No. 638.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	182	7	180	4.52	11.66	52.7	150
B	167	5	180	4.49	11.62	52.2	150
	349	.....	.....	.....	.....	104.9	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.
	Actual.	Pounds per sq. inch.			
	Pounds.		*Inch.*	*Inch.*	*Inch.*
A	26,350	500	.0645	.0002	−.03
B	26,100	500	.0670	.0004	−.02

Test of built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	0.	.....	
100,000	0.	0.	.....	
120,000	0.	0.	.....	
140,000	0.	0.	.....	
160,000	0.	0.	.....	
180,000	−.02	0.	.....	
200,000	−.08	0.	.....	
212,000	−.45	.....	.....	Ultimate strength = 2,021 pounds per square inch.

Failed by horizontal deflection in minus direction. Crushed fibers of stick B at middle.

The deflections increase rapidly soon after the first indications of final failure appear.

No. 640.

Same style of post as No. 638.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	131	7	180	4.53	11.59	5.25	150
B	158	5	180	4.53	11.59	5.25	150
	289	.....	.....	.....	.....	10.50	.....

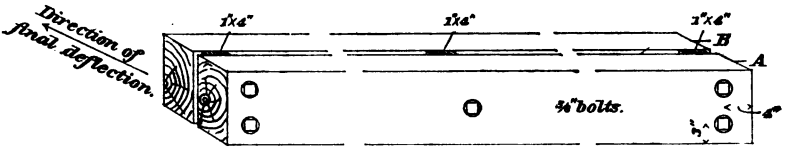
Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.
	Actual.	Pounds per sq. inch.			
	Pounds.		*Inch.*	*Inch.*	*Inch.*
A	26,250	500	.1060	.0015	+ .05
B	26,250	500	.0955	.0010	− .10

Test of built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	− .02	0.	.....	
60,000	− .02	0.	.....	
80,000	− .02	0.	.....	
100,000	0.	0.	.....	
120,000	.01	0.	.....	
140,000	.18	0.	.....	
149,000	1.20	0.	.....	Ultimate strength = 1,419 pounds per square inch.

Failed by horizontal deflection in plus direction.
Deflections increased rapidly when the maximum load was approached.

No. 642.



Preliminary test af single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	192	6	179.98	5.57	11.61	64.7	150
B	306	7	179.98	5.58	11.61	64.7	150
	.....	.....	.....	.....	.....	129.4	.....

Stick.	Loads applied.		Compression.	Compression. set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,350	500	.0770	.0006	.07	0.
B	32,350	500	.0390	— .0007	.08	.05

Test of built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	.01	.....	
80,000	0.	.02	.....	
100,000	0.	.03	.....	
120,000	.01	.04	.....	
140,000	.03	.04	.....	
150,000	.04	.04	.....	
160,000	.06	.04	.....	
170,000	.08	.04	.....	
180,000	.10	.04	.....	
190,000	.11	.02	.....	
200,000	.18	.01	.....	
210,000	.32	0.	.....	
215,000	.72	— .03	.....	Ultimate strength.

Failed by horizontal deflection in plus direction.

Deflections continued to 1″.15 horizontal, the fibers of stick A crushing in the vicinity of knots 16″ and 48″ from end.

643.

Same style of post as No. 642.

Preliminary test of the single sticks.

Stick.	Weight	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	203	17	179.92	5.65	11.61	65.6	150
B	189	5	179.92	5.61	11.62	65.2	150
	392	.....	.....	.....	.....	130.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,800	500	.0440	0.	.02	— .01
B	32,600	500	.0600	.0008	— .02	— .02

Test of built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	.0	0.	.....	
20,000	.0	0.	.....	
40,000	— .01	.05	.....	
60,000	— .01	.08	.....	
80,000	— .01	.10	.....	
100,000	— .01	.12	.....	
120,000	— .01	.12	.....	
140,000	— .02	.13	.....	
160,000	— .02	.14	.....	
180,000	— .02	.16	.....	
200,000	— .05	.18	.....	
220,000	— .07	.20	.....	
230,000	— .09	.21	.....	
240,000	— .10	.22	.....	
250,000	— .15	.25	.....	
255,000	— .19	.25	.....	
260,000	— .29	.29	.....	
261,000	— .45	.30	.....	Ultimate strength = 1,995 lbs. per square inch.

Failed by deflecting horizontally in minus direction and upward.

The deflection was increased horizontally to 1″.20 with changing the vertical.

No. 644.

Same style of post as No. 642.

Preliminary test of single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	227	7	179.96	5.60	11.63	65.1	150
B	236	7	179.96	5.60	11.62	65.1	150
	463	.....	.....	.....	.....	130.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,550	500	.0596	0.	—.02	—.02
B	32,550	500	.0690	.0005	.02	—.01

Test of the built post.

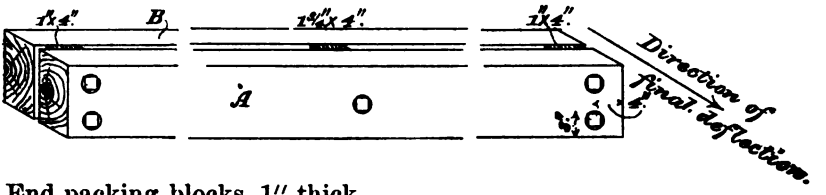
Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	.02	.....	
60,000	0.	.03	.....	
80,000	—.01	.05	.....	
100,000	—.01	.06	.....	
120,000	—.01	.06	.....	
140,000	—.01	.09	.....	
160,000	—.03	.10	.....	
180,000	—.04	.10	.....	
200,000	—.06	.11	.....	
210,000	—.08	.11	.....	
220,000	—.09	.12	.....	
230,000	—.10	.13	.....	
240,000	—.11	.13	.....	
250,000	—.15	.14	.....	
255,000	—.20	.13	.....	
257,800	—.45	.05	.....	Ultimate strength = 1,980 pounds per square inch.

Failed by horizontal deflection in minus direction. Crushed fibers of stick A 12″ from end, and stick B at middle.

The fibers crushing in each case in the vicinity of knots.

No. 648.

Swelled white-pine built post.



End packing blocks, 1″ thick.
Middle packing block, 1¾″ thick.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches*	*Inches.*
A	206	12	180	5.60	11.72	65.6	150
B	203	10	180	5.61	11.72	65.6	150
	409	.....	.....	.....	.....	131.2	.....

Stick.	Loads applied. Actual.	Loads applied. Pounds per sq. inch.	Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,800	500	.0590	.0002	.19	.04
B	32,800	500	.0700	0.	.05	.02

Transversely stick A is the stiffer of the two. When the post is bolted up, A deflects ″.34; B deflects ″.41.

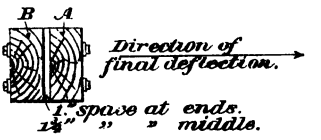
Test of built post.

Loads applied.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	—.01	0.	.....	
80,000	—.02	0.	.....	
100,000	—.05	0.	.....	
120,000	—.07	0.	.....	
140,000	—.08	0.	.....	
160,000	—.10	0.	.....	
180,000	—.13	—.02	.....	
200,000	—.17	—.04	.....	
210,000	—.19	—.06	.....	
220,000	—.21	—.06	.....	
230,000	—.23	—.08	.....	
240,000	—.28	—.10	.....	
250,000	—.19	—.18	.....	
260,000	—.07	—.25	.....	
268,000	.....	.....	.....	Ultimate strength.

Stick B failed. Fibers crushed at a group of 5 knots 14″ from middle. Size of largest knot, 1½″ diameter.

No. 649.

Same style of post as No. 648.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	187	9	180	5.60	11.71	65.6	150
B	184	4	180	5.61	11.74	65.9	150
	371	.....	.....	.....	.....	131.5	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch*
A	32,800	500	.0600	.0002	— .19	— .03
B	32,950	500	.0705	.0008	.34	.05

Test of the built post.

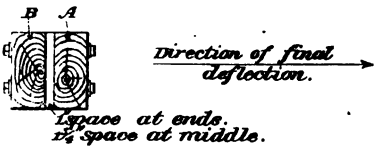
Transversely when the post is bolted up.
Stick A deflects ".39." } Middle bolt has washers 4" diameter.
Stick B deflects ".36." }

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	.01	.01	.....	
60,000	.02	.02	.....	
80,000	.02	.02	.....	
100,000	.02	.05	.....	
120,000	.02	.08	.....	
140,000	.02	.09	.....	
160,000	.02	.10	.....	
180,000	0.	.11	.....	
200,000	0.	.12	.....	
210,000	— .01	.14	.....	
220,000	— .02	.15	.....	
230,000	— .02	.16	.....	
240,000	— .05	.18	.....	
250,000	— .06	.18	.....	
260,000	— .10	.20	.....	
265,000	— .15	.21	.....	
270,000	— .25	.22	.....	
275,000	— .38	.24	.....	
277,000	Ab't— .80	.24	.....	Ultimate strength = 2,107 pounds per square inch.

Failed by horizontal deflection, minus direction.
Fibers of stick A crushed at middle of post.

No. 650.

Same style of post as No. 648.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq inches.*	*Inches.*
A	194	12	180	5.61	11.75	65.9	150
B	190	9	180	5.61	11.71	65.7	150
	384	.....	.....	.....	.....	131.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,950	500	.0530	0.	− .22	− .04
B	32,850	500	.0885	.0008	.17	.04

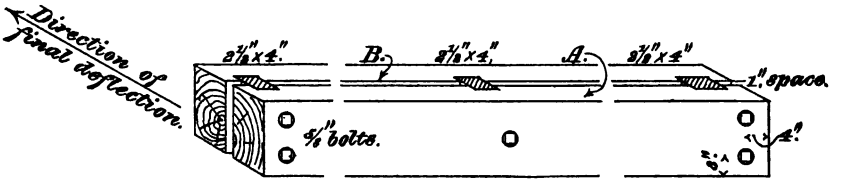
When bolted together stick A deflected ".32.
When bolted together stick B deflected ".43.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	− .01	.01	.....	
60,000	− .04	.02	.....	
80,000	− .05	.04	.....	
100,000	− .06	.04	.....	
120,000	− .07	.05	.....	Post rotated over half revolution.
10,000	− .01	0.	.....	
50,000	+ .02	+ .01	.....	
100,000	+ .06	+ .05	.....	
120,000	+ .08	+ .05	.....	
140,000	+ .09	+ .06	.....	
160,000	+ .10	+ .06	.....	
180,000	+ .12	+ .07	.....	
200,000	+ .15	+ .09	.....	
210,000	+ .20	+ .10	.....	
220,000	+ .21	+ .10	.....	
230,000	+ .26	+ .10	.....	
240,000	+ .31	+ .10	.....	Ultimate strength = 1,824 pounds per square inch.

Failed by horizontal deflection, stick B being on the concave side.
Fibers of each stick crushed at middle in the vicinity of some knots.

No. 645.



Oak packings let into each stick ¾".

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	215	5	179.97	5.59	11.59	64.8	150
B	266	7	179.97	5.60	11.60	65.0	150
	481	.....	.....	.....	.....	129.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,400	500	.0560	.0006	−.02	0.
B	32,500	500	.0540	0.	.02	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	.01	.....	
60,000	0.	.02	.....	
80,000	0.	.02	.....	
100,000	0.	.02	.....	
120,000	0.	.01	.....	
140,000	0.	.01	.....	
160,000	0.	.01	.....	
180,000	0.	0.	.....	
200,000	.01	.01	.....	
210,000	.01	.01	.....	
220,000	.01	.01	.....	
230,000	.01	.01	.....	
240,000	.02	.01	.....	
250,000	.05	.01	.....	
260,000	.10	.01	.....	
263,200	.30	.01	.....	Ultimate strength = 2,028 pounds per square inch.

Failed by horizontal deflection in plus direction.

Fibers of both sticks crushed at middle, where bolt passes through, and where the sticks are further weakened by cutting away ¾" of wood to receive packing block.

No. 646.

Same style of post as No. 645.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	206	6	180	5.59	11.61	64.9	150
B	204	12	180	5.60	11.62	65.1	150
	410	.....	.....	.....	.....	130.0	.....

Stick.	Loads applied. Actual.	Loads applied. Pounds per square inch.	Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,450	500	.0493	0.	0.	— .01
B	32,550	500	.0620	.0005	— .02	— .01

Test of the built post.

Loads applied.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	.02	.....	
40,000	0.	.05	.....	
60,000	0.	.06	.....	
80,000	0.	.07	.....	
100,000	0.	.07	.....	
120,000	0.	.07	.....	
140,000	0.	.08	.....	
160,000	— .01	.08	.....	
180,000	— .02	.08	.....	
200,000	— .03	.08	.....	
210,000	— .05	.08	.....	
220,000	— .07	.08	.....	
230,000	— .11	.08	.....	
240,000	— .20	.07	.....	
249,000	— .42	.02	.....	Ultimate strength = 1,915 lbs. per square inch.

Failed by horizontal deflection in minus direction.

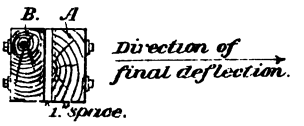
The post took a sharp bend at the middle, crushing the fibers of stick B, and splitting stick A at the middle packing block.

Stick A crushed the fibers 10″ from end in the vicinity of knots.

During the preliminary test of the single sticks an end section (2″ × 11″.61) beyond the notched recess for packing block was accidentally split off. This piece was nailed on again. It passed through the test without disturbance, showing that it carried very little shearing load when tested in this manner between flat rigid platforms.

No. 647.

Same style of post as No. 645.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	192	11	180	5.62	11.62	65.3	150
B	192	13	180	5.62	11.62	65.3	150
	384					130.6	

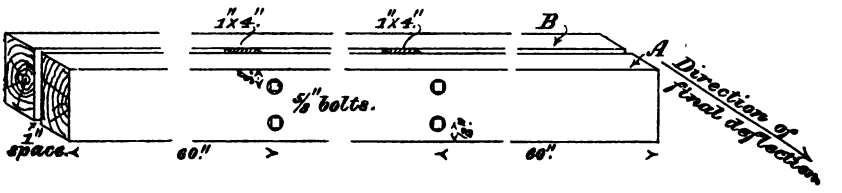
Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,650	500	.0630	.0006	0.	—.01
B	32,650	500	.0700	.0005	.03	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.		
20,000	0.	0.		
40,000	0.	0.		
60,000	0.	0.		
80,000	—.02	.01		
100,000	—.05	.01		
120,000	—.06	.02		
140,000	—.07	.03		
160,000	—.10	.05		
180,000	—.11	.06		
200,000	—.15	.08		
210,000	—.19	.10		
220,000	—.20	.10		
230,000	—.26	.11		
240,000	—.35	.12		
248,000	—.72	.15		Ultimate strength = 1,899 pounds per square inch.

Failed by horizontal deflection in minus direction.
Stick A split fibers at middle.

No. 678.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	251	16	179.94	5.58	11.47	64.0	150
B	215	8	179.94	5.57	11.45	63.8	150
	466	.....	.....	.....	.....	127.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,000	500	.0529	0.	0.	0.
B	31,900	500	.0642	.0005	—.07	.01

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	—.01	.....	
40,000	—.01	—.02	.....	
60,000	—.03	—.03	.....	
80,000	—.05	—.04	.....	
100,000	—.06	—.05	.05	
120,000	—.07	—.05	.....	
140,000	—.09	—.06	.....	
160,000	—.10	—.07	.....	
180,000	—.13	—.08	.....	
200,000	—.16	—.09	.10	
220,000	—.21	—.10	.....	
230,000	—.27	—.10	.....	
240,000	—.36	—.11	.....	
245,500	—.57	—.14	.....	Ultimate strength = 1,921 pounds per square inch.

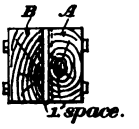
Failed by horizontal deflection, minus direction.

Fibers crushed near the south end of post at some knots.

Stick A fa lêd 8″ from end, stick B 2″ from end and at bolt-holes, which were bored alongside a knot.

No. 679.

Same style of post as No. 678.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	209	12	180	5.62	11.76	66.1	150
B	190	7	180	5.62	11.72	65.9	150
	399	.....	.....	.....	.....	132.0	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	33,050	500	.0664	.0010	.05	0.
B	32,950	500	.0705	.0003	—.05	—.01

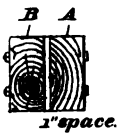
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	.01	.....	
100,000	0.	.01	.04	
120,000	0.	.02	.....	
140,000	0.	.04	.....	
160,000	0.	.05	.....	
180,000	0.	.05	.....	
200,000	0.	.06	.10	
210,000	.01	.07	.....	
220,000	.01	.07	.....	
230,000	.02	.08	.....	
240,000	.02	.08	.....	
249,000	.05	.08	.....	Ultimate strength = 1,886 lbs. per square inch.

Stick A failed at bolt-holes. Stick B failed at bolt-holes and at a group of knots 12″ from bolt-holes.

No. 680.

Same style of post as No. 678.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Ganged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	268	8	180	5.60	11.72	65.6	150
B	278	8	180	5.61	11.73	65.8	150
	546	.....	.....	.....	.....	131.4	.....

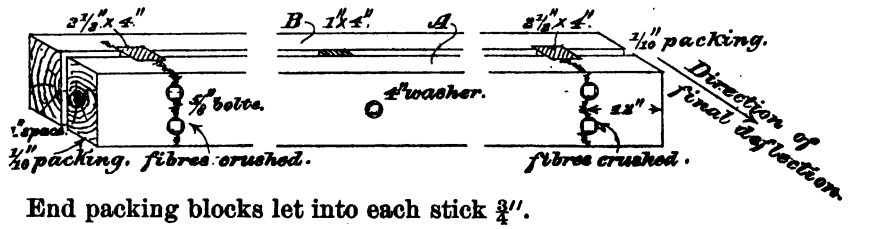
Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,800	500	.0650	.0069	—.08	0.
B	32,900	500	.0495	0.	0.	—.02

Test of the built post.

Loads applied.	Deflection.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	0.	.....	
100,000	0.	0.	0.	
120,000	0.	0.	.....	
140,000	0.	0.	.....	
160,000	0.	0.	.....	
180,000	0.	0.	.....	
200,000	0.	0.	.05	
210,000	0.	0.	.....	
220,000	0.	0.	.....	
230,000	0.	0.	.....	
240,000	0.	0.	.....	
250,000	0.	0.	.....	
260,000	—.01	0.	.....	
270,000	—.02	0.	.....	
278,000	.....	.....	.....	Ultimate strength = 2,116 lbs. per square inch.

Stick A failed at knots 40″ and 66″ from end. Stick B failed at knots 12″ from middle.

No. 663.



End packing blocks let into each stick $\frac{3}{4}''$.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	230	14	180	5.60	11.75	65.8	150
B	208	6	180	5.63	11.75	66.2	150
	438	.....	.....	.....	.....	132.0	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,900	500	.0621	.0005	.02	—.01
B	33,100	500	.0657	.0010	—.06	0.

Test of the built post.

Tested with uneven bearings.

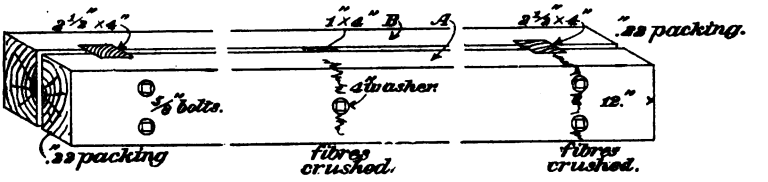
Yellow-pine strip ".1 thick placed behind north end of stick A. Same amount of packing placed behind south end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	—.01	0.	.....	Ends not packed came to full bearing.
30,000	—.03	0.	.....	
40,000	—.03	0.	.....	
60,000	—.04	0.	.....	
80,000	—.05	0.	.....	
100,000	—.05	0.	.....	
120,000	—.05	0.	—.01	
140,000	—.05	0.	.....	
160,000	—.05	0.	.....	
180,000	—.05	+.01	.....	
200,000	—.05	+.01	—.05	
210,000	—.03	+.01	.....	
220,000	—.03	+.01	.....	
230,000	—.01	+.01	.....	
240,000	0.	+.01	.....	
250,000	+.01	.02	—.07	
260,000	.07	.02	.....	
270,000	.09	.02	.....	
280,000	.02	—.01	—.07	
290,000	—.01	—.02	.....	
300,000	—.21	—.05	.....	Ultimate strength=2,273 pounds per square inch.

Final deflection took place in minus horizontal direction. Loads were continued after passing the maximum till the horizontal deflection was

increased to —1″.10, developing lines of failure by crushing the fibers at the notched ends of stick A.

No. 676.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	201	12	179.94	5.60	11.71	65.6	150
B	184	6	179.94	5.61	11.73	65.8	150
	385	.....	.....	.....	.....	131.4	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,800	500	.0530	.0003	.06	.01
B	32,900	500	.0593	0.	— .05	0.

Test of the built post.

Tested with uneven bearings.

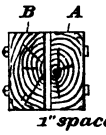
Strip of yellow pine ″.22 thick placed behind north end of stick A. Same amount of packing placed behind south end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	— .05	+ .01	.....	North end of stick B reached a full bearing at 26,000 pounds.
30,000	— .10	+ .01	.....	
40,000	— .12	+ .01	.....	
50,000	— .12	+ .01	.....	South end of stick A reached a bearing at 33,000 pounds.
60,000	— .12	+ .02	.....	
80,000	— .11	+ .03	.....	
100,000	— .09	+ .05	— .04	
120,000	— .08	.09	.....	
140,000	— .07	.10	.....	
160,000	— .06	.11	.....	
180,000	— .05	.11	.....	
200,000	— .04	.11	— .06	
220,000	— .04	.11	.....	
230,000	— .03	.10	.....	
240,000	— .05	.10	.....	
250,000	— .06	.10	.....	
260,000	— .09	.08	.....	
270,000	— .10	.08	.....	
274,500	— .11	.....	.....	Ultimate strength = 2,089 pounds per square inch.

Failed by crushing the fibers of stick A at notch 12″ from south end and at the middle.

No. 677.

Same style of post as No. 676.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Ganged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	185	6	180	5.61	11.72	65.7	150
B	193	6	180	5.58	11.72	65.4	150
	378	.....	.....	.....	.....	131.1	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,850	500	.0551	.0004	.07	0.
B	32,700	500	.0625	.0005	— .03	.....

Test of the built post.

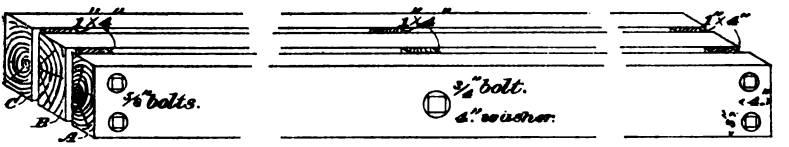
Tested with uneven bearings. Yellow-pine stick ".32 thick placed behind north end of stick A. Same amount of packing used behind south end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	— .01	.01	.....	
30,000	— .06	.04	.....	
40,000	— .07	.04	.....	
50,000	— .97	.03	.02	
60,000	— .07	.03	.....	
80,000	— .05	.03	.....	
100,000	— .03	.03	.....	
120,000	— .01	.03	.....	
140,000	— .01	.04	.....	
160,000	0.	.02	.....	
180,000	0.	.04	.....	
200,000	0.	.04	.....	
220,000	0.	.04	.....	
240,000	— .01	.04	.....	
250,000	— .02	.04	.07	
255,000	.16	.07	.....	Ultimate strength=1,945 pounds per square inch.

Stick A failed at a group of knots 15" from end.

Stick B failed at knots 40" from end; also fibers crushed where the stick was notched to receive packing block.

No. 690.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	175	18	180	4.52	11.62	52.5	150
B	226	11	180	5.56	11.70	65.0	150
C	199	18	180	4.46	11.62	51.8	150
	600	.....	.....	.....	.....	169.3	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,250	500	.0460	0.	.18	.01
B	32,500	500	.0580	.0008	—.02	0.
C	25,900	500	.0480	.0008	.20	.02

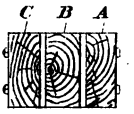
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	—.04	.01	.....	
40,000	—.07	.03	.....	
60,000	—.06	.03	.....	
80,000	—.05	.05	.....	
100,000	.05	.05	.05	
140,000	.04	.06	.....	
180,000	.03	.07	.....	
200,000	.02	.08	.08	
220,000	0.	.09	.....	
240,000	0.	.10	.....	
260,000	—.02	.11	.....	
280,000	—.06	.11	.....	
300,000	—.12	.12	.....	
310,000	—.32	.16	.....	Ultimate strength = 1,831 lbs. per square inch.

Stick A failed at a knot 54″ from the end of post.
Stick B failed at a knot 33″ from the end of post.

No. 691.

Same style of post as No. 690.



1" spaces.

Preliminary test of the single sticks.

Stick.	Weight.	Ring per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	164	9	179.98	4.48	11.60	52.0	150
B	197	14	179.98	5.56	11.60	64.5	150
C	159	12	179.98	4.45	11.61	51.7	150
	520	.....	.....	.....	.....	168.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,000	500	.0526	.0010	—.15	0.
B	32,250	500	.0430	.0002	0.	—.01
C	25,850	500	.0390	.0002	.01	.01

Test of the built post.

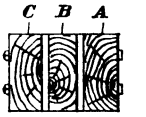
Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	.02	.....	
40,000	—.01	.03	.....	
60,000	—.02	.03	.....	
80,000	—.02	.02	.....	
100,000	—.03	.01	.07	
140,000	—.04	.01	.....	
180,000	—.06	0.	.....	
200,000	—.07	0.	.10	
220,000	—.07	0.	.....	
240,000	—.08	0.	.....	
260,000	—.09	0.	.....	
280,000	—.10	0.	.....	
300,000	—.11	0.	.....	
310,000	—.14	0.	.....	
320,000	—.16	0.	.....	
330,000	—.17	0.	.....	
340,000	—.20	0.	.....	
350,000	—.21	.01	.....	
360,000	—.28	.03	.....	
372,500	—.50	.....	.....	Ultimate strength = 2,215 lbs. per square inch.

Stick A crushed 22″ from middle.

Stick C crushed 8″ from middle, both failures occurring in the vicinity of knots.

No. 692.

Same style of post as No. 690, except two outside sticks got out of 6″×12″ timber, middle stick got out of 5″×12″ timber.



Preliminary test of the single sticks.

Stick.	Weight.	Ring per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	248	13	177.25	5.62	11.60	65.2	150
B	153	12	177.25	4.59	11.60	52.2	150
C	213	5	177.25	5.60	11.57	64.8	150
	614	.....	.....	.....	.....	182.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,600	500	.0580	.0001	.06	.01
B	26,100	500	.0641	.0006	.08	.01
C	32,400	500	.0768	.0012	—.06	0.

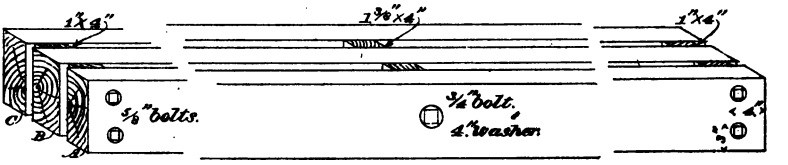
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	.01	0.	.....	
80,000	.01	.01	.....	
100,000	.01	.03	.05	
140,000	.01	.06	.....	
180,000	0.	.09	.....	
200,000	0.	.09	—.10	
220,000	.01	.10	.....	
240,000	—.02	.10	.....	
260,000	—.04	.11	.....	
280,000	—.05	.12	.....	
300,000	—.07	.12	—.15	
310,000	—.08	.13	.....	
320,000	—.07	.16	.....	
330,000	—.07	.19	—.27	
340,000	—.09	.20	.....	
350,000	—.11	.21	.....	
360,000	—.18	.21	.....	
363,000	—.89	.21	.....	Ultimate strength=1,992 pounds per square inch.

Stick C failed at a knot 1¼″ diameter, 10″ from middle.
Stick B failed at a group of knots 8″ from middle.

No. 687.

SWELLED POST.



1″ spaces at ends.
1⅜″ spaces at middle.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	151	11	180	4.50	11.60	52.2	150
B	218	8	180	5.58	11.62	64.8	150
C	167	9	180	4.52	11.59	52.4	150
	536	.....	.....	.....	.....	169.4	....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,100	500	.0460	0.	—.27	0.
B	32,400	500	.0587	.0007	.02	0.
C	26,200	500	.0533	.0008	.25	.02

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	
20,000	.02	.03	0.	
40,000	.01	.04	.....	
60,000	.01	.05	.....	
80,000	.01	.06	.....	
100,000	.01	.07	.03	
140,000	0.	.08	.....	
180,000	0.	.08	.....	
200,000	—.01	.08	.05	
220,000	—.01	.08	.....	
240,000	—.04	.07	.....	
260,000	—.05	.08	.....	
280,000	—.08	.10	.....	
300,000	—.10	.08	.07	
320,000	—.21	.09	.....	
325,500	—.34	.09	.....	Ultimate strength = 1,919 pounds per square inch.

Fibers of stick A failed at a knot 12″ from middle. Stick C crushed fibers at a knot at middle of post.

No. 688.

Same style of post as No. 687.

Direction of final deflection.

1" spaces at ends.
1⅛" " " middle.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	176	10	180	4.50	11.60	52.2	150
B	236	10	180	5.62	11.60	65.2	150
C	163	11	180	4.50	11.60	52.2	150
	575	.....	.....	.....	.....	169.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,100	500	.0565	.0002	—.29	—.01
B	32,600	500	.0645	0.	—.10	—.01
C	26,100	500	.0703	.0003	.29	.03

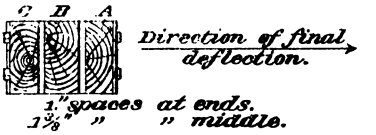
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	0.	.....	Sticks A and B have poor appearance; color of wood dull, lifeless. Stick B contains 15 knots from ¾" to 1¼" diameter.
40,000	0.	.02	.....	
60,000	0.	.05	.....	
80,000	0.	.06	.....	
100,000	0.	.07	—.08	
140,000	—.01	.08	.....	
180,000	—.01	.08	.....	
200,000	—.02	.08	.....	
220,000	—.03	.08	.....	
240,000	—.04	.08	.....	
260,000	—.06	.08	.....	
280,000	—.10	.06	.....	
300,000	—.21	.06	.....	
306,000	—.40	.06	.....	Ultimate strength = 1,804 pounds per square inch.

Failed by horizontal deflection, minus direction. Stick B failed at a knot at middle.

No. 689.

Same style of post as No. 687.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	188	7	180.05	4.48	11.60	52.0	150
B	203	11	180.05	5.60	11.62	65.1	150
C	159	9	180.05	4.46	11.57	51.6	150
	550	.....	.....	.....	.....	168.7	.....

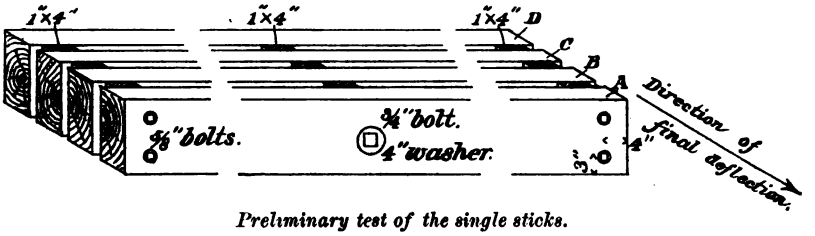
Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,000	500	.0510	.0008	— .03	0.
B	32,550	500	.0660	.0002	— .10	0.
C	25,800	500	.0789	.0015	.26	.04

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.05	.02	0.	
40,000	.05	.04	.....	
60,000	.04	.06	.....	Stick C has 20 knots in it from ¾" to 1¼" diameter.
80,000	.04	.06	.....	
100,000	.03	.06	— .07	
140,000	.03	.07	.....	
180,000	.02	.09	.....	
200,000	.01	.10	— .10	
220,000	.01	.11	.....	
240,000	0.	.11	.....	
260,000	0.	.11	.....	
280,000	— .01	.12	.....	
300,000	.01	.12	—.13	
320,000	— .04	.14	.....	
340,000	— .14	.15	.....	Ultimate strength = 2,015 pounds per square inch.

Sustained maximum load 3 minutes, increasing horizontal deflection from — ".14 to — ".60.

No. 681



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	193	5	179.95	4.47	11.60	51.9	150
B	192	5	179.95	4.52	11.65	52.7	150
C	146	9	179.95	4.48	11.65	52.2	150
D	157	9	179.95	4.51	11.65	52.5	150
	688	.....	.....	.....	.....	209.3	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,950	500	.0700	.0008	— .04	0.
B	26,350	500	.0714	.0003	.06	0.
C	26,100	500	.0531	.0004	— .12	0.
D	26,250	500	.0762	.0006	0.	.01

Test of the built post.

Loads applied.	Loads per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	0.	0.	0.	Compression measured for 150″ on stick A.
104,650	500	.0575	.....	.....	.....	.....	
0	0	.....	0.	.....	.....	.....	
20,000	.....	.....	.....	0.	.02	.....	
40,000	.....	.....	.....	0.	.05	.....	
60,000	.....	.....	.....	0.	.06	.....	
80,000	.....	.....	.....	0.	.07	.....	
100,000	.....	.....	.....	0.	.08	— .07	
140,000	.....	.....	.....	0.	.09	.....	
180,000	.....	.....	.....	— .01	.10	.....	
200,000	.....	.....	.....	— .02	.10	— .05	
240,000	.....	.....	.....	— .05	.10	.....	
280,000	.....	.....	.....	— .08	.10	.....	
300,000	.....	.....	.....	— .10	.11	— .06	
340,000	.....	.....	.....	— .18	.12	.....	
350,000	.....	.....	.....	— .26	.12	.....	
360,000	.....	.....	.....	— .38	.13	.....	
363,000	1,734	.....	.....	.....	.....	.....	Ultimate strength.

Failed by horizontal deflection, minus direction; fibers of sticks B and C crushed at middle of post, at some knots.

No. 682.

Same style of post as No. 681.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	161	7	180	4.50	11.63	52.3	150
B	156	14	180	4.50	11.64	52.4	150
C	163	7	180	4.49	11.60	52.1	150
D	151	9	180	4.50	11.63	52.3	150
	631	.....	.....	.....	.....	209.1	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,150	500	.0612	.0005	0.	0.
B	26,200	500	.0546	.0004	—.06	—.01
C	26,050	500	.0542	.0002	0.	0.
D	26,150	500	.0916	.0007	0.	0.

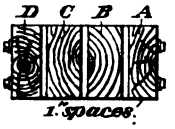
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.02	.03	.....	
40,000	.02	.09	—.09	
60,000	.02	.10	.....	
80,000	.02	.10	.....	
100,000	.02	.10	.....	
140,000	.01	.10	.....	
180,000	0.	.10	.....	
200,000	0.	.10	—.07	
240,000	—.01	.10	.....	
280,000	—.02	.10	.....	
300,000	—.03	.10	—.04	
340,000	—.07	.09	.....	
360,000	—.11	.07	.....	
380,000	—.17	.10	.....	
400,000	—.26	.08	0.	
410,000	—.50	.10	.....	
414,000	—.70	.....	.....	Ultimate strength=1,980 pounds per square inch.

Post deflected horizontally, minus direction.
Stick D crushed at knots 24″ from middle.

No. 683.

Same style of post as No. 681.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	169	10	180.03	4.46	11.63	51.9	150
B	219	11	180.03	5.62	11.69	65.7	150
C	218	9	180.03	5.60	11.70	65.5	150
D	181	7	180.03	4.46	11.61	51.8	150
	.....	.....	.....	.....	.....	234.9	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,950	500	.0570	0.	.01	0.
B	32,850	500	.0530	.0002	0.	0.
C	32,750	500	.0494	.0008	.04	0.
D	25,900	500	.0590	0.	—.04	0.

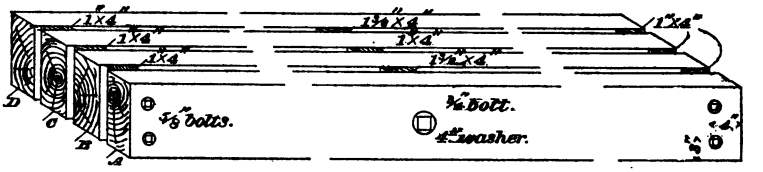
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	0.	.....	
100,000	0.	.01	0.	
140,000	0.	.02	.....	
180,000	0.	.02	.....	
200,000	0.	.02	.04	
240,000	0.	.02	.....	
280,000	0.	.02	.....	
300,000	—.01	.02	.....	
340,000	—.01	.02	.....	
380,000	—.01	.02	.....	
400,000	—.01	.02	.....	
420,000	0.	.02	.....	
440,000	0.	.02	.....	
460,000	.01	.02	.....	
480,000	.04	.02	.....	
500,000	.13	.02	.13	
501,000	.....	.....	.....	Ultimate strength = 2,133 pounds per square inch.

Stick A crushed 24″ from middle.
Stick B crushed 26″ from middle.
Stick C crushed 8″ from middle.
All failures occurring in the vicinity of knots.

No. 684.

SWELLED POST.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	146	10	180	4.50	11.64	52.4	150
B	210	12	180	5.64	11.59	65.4	150
C	234	7	180	5.60	11.58	64.8	150
D	166	10	180	4.48	11.61	52.0	150
	756	.....	.....	.....	.....	234.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,200	500	.0664	.0006	—.18	0.
B	32,700	500	.0610	.0004	.03	0.
C	32,400	500	.0548	0.	0.	.01
D	26,000	500	.0514	.0002	.32	.01

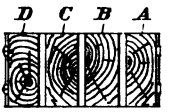
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	.01	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	—.01	.....	
100,000	0.	—.02	.02	
140,000	0.	—.04	.....	
180,000	0.	—.04	.....	
200,000	0.	—.04	.05	
240,000	0.	—.04	.....	
280,000	0.	—.05	.....	
300,000	0.	—.05	.09	
340,000	0.	—.05	.....	
380,000	0.	—.05	.....	
400,000	0.	—.06	.12	
430,000	.01	—.06	.....	
440,000	.03	—.06	.....	
450,000	.03	—.07	.....	
460,000	.04	—.07	.....	
470,000	.06	—.08	.....	
480,000	.08	—.08	.....	
490,000	.10	—.08	.....	
500,000	.10	—.08	.....	
510,000	.15	—.08	.....	
520,000	.20	—.08	.....	
529,000	.45	—.08	.....	Ultimate strength = 2,255 pounds per square inch.

Stick A, fibers crushed at middle.
Stick B, fibers crushed 32″ from middle.
Stick C, fibers crushed 8″ from middle of post.

No. 685.

Same style of post as No. 684.



End spaces 1″ each,
inside middle space 1″,
outside „ spaces 1⅜″ each.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	145	10	180	4.50	11.60	52.2	150
B	220	10	180	5.63	11.62	65.4	150
C	209	12	180	5.61	11.62	65.2	150
D	166	9	180	4.48	11.62	52.0	150
	740	.....	.....	.....	.....	234.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,100	500	.0645	.0005	— .30	0.
B	32,760	500	.0650	.0002	.07	.01
C	32,600	500	.0506	.0004	.05	0.
D	26,000	500	.0546	.0005	.35	.02

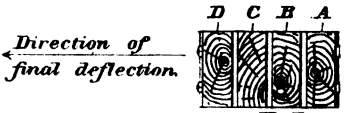
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.02	.03	.02	
40,000	.03	.05	.....	
60,000	.03	.05	.....	
80,000	.03	.05	.....	
100,000	.03	.05	.....	
140,000	.04	.05	.....	
180,000	.05	.05	.....	
200,000	.05	.05	.11	
240,000	.07	.05	.....	
280,000	.09	.05	.....	
300,000	.10	.05	.11	
340,000	.12	.05	.....	
380,000	.15	.05	.....	
400,000	.17	.05	.....	
420,000	.13	.05	.....	
430,000	.04	.05	.....	Ultimate strength = 1,831 pounds per square inch.

Sticks A and C failed at some knots 42″ from the north end of the pots.

No. 686.

Same style of post as No. 684.



End spaces 1" each,
inside middle space 1",
outside " spaces 1⅛" each.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	145	11	180	4.48	11.61	52.0	150
B	183	10	180	4.50	11.56	52.0	150
C	159	12	180	4.50	11.36	51.1	150
D	150	8	180	4.52	11.61	52.5	150
	637	.....	.....	.....	.....	207.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,000	500	.0500	.0002	−.25	−.02
B	26,000	500	.0315	0.	.07	.01
C	25,550	500	.0543	.0002	.02	.01
D	26,250	500	.0680	.0005	.05	.01

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	0.	.05	0.	Stick A has very poor appearance. Dead wood along the corner about 3 square inches area.
40,000	0.	.10	.....	
60,000	0.	.13	.....	
80,000	0.	.14	.....	
100,000	.01	.15	0.	
120,000	.01	.14	.....	
140,000	.02	.14	.....	
160,000	.02	.14	.....	
180,000	.02	.14	.....	
200,000	.03	.14	.....	
220,000	.04	.14	.....	
240,000	.04	.14	.01	
260,000	.04	.14	.....	
280,000	.05	.14	.....	
300,000	.06	.13	.....	
320,000	.07	.13	.....	
340,000	.09	.12	.....	
360,000	.11	.11	.04	
380,000	.17	.11	.....	
395,000	Ab't. 30	.....	.....	Ultimate strength = 1,903 pounds per square inch.

Failed by horizontal deflection in plus direction. Horizontal deflection increased rapidly when the ultimate load was reached. Fibers of stick A crushed at the ¾″ bolt-hole, and in vicinity of two knots ¾″ diameter at middle, a sharp bend occurring at this point.

COMPRESSION OF WHITE PINE POSTS.

TABULATED RESULTS.

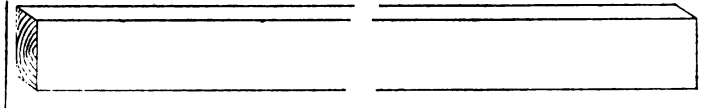
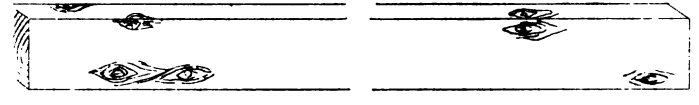
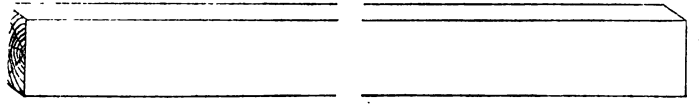
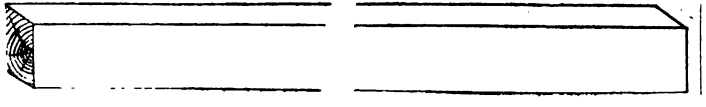
Number of test.	Weight.	Average rate of growth.	Size of post.			Sectional area.	Ultimate strength.		Manner of failure.
			Length.	Width.	Depth.		Actual.	Pounds per square inch.	
	Pounds.	*Rings per inch.*	*Ft. In.*	*Inches.*	*Inches.*	*Square inches.*	*Pounds.*		
511	7		15	5.50	5.50	30.25	108,000	3,570	Fibers crushed.
491	26⅛		4 11.95	5.48	5.48	30	111,000	3,700	Failed at a knot 14″ from end of post.
492	31		5 .05	5.48	5.48	30	99,300	3,100	Failed at a knot 15″ from end of post.
493	43½		7 6.10	5.50	5.52	30.4	67,400	2,217	Failed at knots 28″ from end of post.
494	37⅞		7 6.10	5.47	5.47	29.9	70,800	2,368	Failed at knots 16″ from end of post.
495	45		7 6.10	5.50	5.45	29.8	74,100	2,487	Failed at knots 20″ and 25″ from end of post.
512	62⅛		10 .10	5.48	5.49	30.1	82,000	2,724	Failed at knots 40″ from end of post.
519	49⅞		10 .10	5.48	5.42	29.7	75,400	2,539	Failed at knots near middle of post.
520	59⅛		10 .10	5.45	5.45	29.7	61,700	2,077	Failed at knots 30″ from end of post.
516	60		12 6.15	5.46	5.46	29.8	68,000	2,282	Failed at knots 64″ from end of post.
517	70		12 6.16	5.50	5.50	30.25	70,800	2,340	Failed at knots 58″ from end of post.
518	67½		12 6.10	5.48	5.52	30.25	100,000	3,306	Failed at knots 31″ from end of post.
513	84⅛		15 .27	5.47	5.47	29.9	54,000	1,806	Failed at knots 66″ from end of post.
514	90		15 .31	5.48	5.48	30	93,500	3,117	Deflected diagonally and failed at knots.
515	91		15 .28	5.33	5.33	28.4	94,000	3,310	Do.
521	96⅛		17 6.24	5.35	5.35	28.6	53,000	1,853	Do.
522	101		17 6.25	5.40	5.38	29	40,500	1,396	Deflected downward; wind-shake on concave side.
523	95		17 6.22	5.33	5.35	28.5	64,800	2,274	Deflected horizontally.
524	109⅛		20 .25	5.28	5.26	27.8	45,000	1,619	Deflected diagonally.
525	106⅛		20 .27	5.29	5.27	27.9	39,500	1,416	Do.
526	95		20 .28	5.25	5.29	27.8	37,000	1,331	Deflected horizontally.
505	110		22 6.26	5.16	5.18	26.7	37,000	1,386	Do.
506	113		22 6.23	5.20	5 22	27.1	37,200	1,373	Do.
507	118		22 6.26	5.18	5.18	26.8	46,700	1,743	Do.
502	127		25 .31	5.27	5.25	27.7	30,900	1,116	Deflected diagonally.
503	125		25 .34	5.25	5.25	27.6	25,800	935	Deflected sideways.
504	127		25 .37	5.25	5.25	27.6	22,200	804	Deflected diagonally.
496	169		27 6.35	5.32	5.34	28.4	32,500	1,144	Do.
497	173		27 6.40	5.35	5.35	28.6	32,000	1,119	Do.
498	157		27 6.30	5.35	5.35	28.6	28,000	979	Do.
569	94		6 8.07	7.77	9.64	74.9	204,000	2,724	Failed at knots 10″ from middle of post.
570	93	7	6 8.10	7.70	9.70	74.7	177,000	2,369	Failed at knots near middle of post.
571	120⅛	12	6 8.13	7.73	9.63	74.4	185,000	2,487	Failed at knots 9″ from end of post.
575	160	15	10 .18	7.75	9.62	74.6	186,000	2,493	Failed at knots 21″ from end of post.

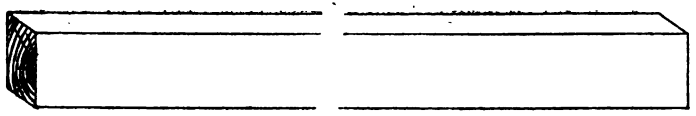
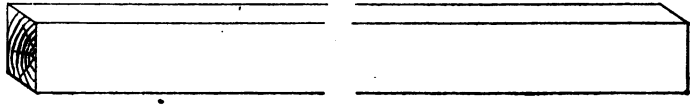
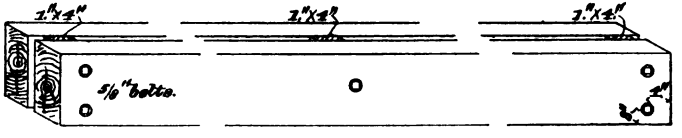
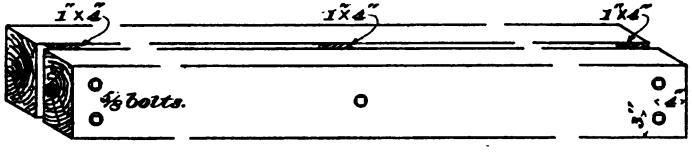
576	166	11	10	.16	7.72	9.76	75.3	204,600	2,717	Failed at knots 13″ and 27″ from end of post.
577	160	10	10	.13	7.73	9.74	75.3	135,000	1,793	Failed at knots 8″ and 11″ from end of post.
581	221	7	13	4.12	7.75	9.75	75.6	168,000	2,222	Failed at knots 14″ and 44″ from end of post.
582	182	3	13	4.14	7.75	9.75	75.6	127,500	1,687	Failed at knots 13″ and 18″ from end of post.
583	196½	13	13	4.14	7.48	9.23	69.0	208,500	3,022	Failed at knots 50″ from end of post.
590	242	7	16	8.20	7.72	9.63	74.3	161,000	2,167	Failed at knots 20″ from end of post.
591	210½	9	16	8.22	7.78	9.58	74.5	163,000	2,188	Failed at knots near middle of post.
592	274	8	16	8.21	7.75	9.75	75.6	175,300	2,319	Failed at knots 75″ from end of post.
533	278	.....	20	.24	7.59	9.62	73.0	140,000	1,918	Deflected horizontally.
534	285	.....	20	.26	7.38	9.29	68.6	166,000	2,420	Failed at knot near middle of post.
535	295	.....	20	.25	7.39	9.27	68.5	206,000	3,007	Failed at knot 24″ from middle of post.
539	352	.....	23	4.20	7.73	9.75	75.4	140,000	1,857	Deflected horizontally.
540	357	.....	23	4.20	7.72	9.61	74.2	170,000	2,291	Do.
541	340	.....	23	4.18	7.63	9.50	72.5	150,000	2,069	Deflected diagonally.
536	427	.....	26	8.20	7.46	9.36	69.8	169,000	2,421	Deflected horizontally.
537	397	.....	26	8.39	7.49	9.34	70.0	140,000	2,000	Do.
538	384	.....	26	8.27	7.46	9.37	69.9	134,000	1,917	Deflected horizontally; knots on concave side.
702	300	10	15	.02	5.60	15.58	87.2	159,000	1,823	Failed at knots 23″ from end of post.
703	267	5	15	.08	5.61	15.60	87.5	168,500	1,926	Deflected horizontally.
704	267	12	15	.00	5.65	15.60	88.1	165,000	1,873	Do.
699	356	7	15	.00	6.60	15.64	103.2	240,000	2,326	Failed at knots 40″ from end of post.
700	395	10	14	11.94	6.60	15.64	103.2	239,000	2,316	Failed at knots 10″ and 60″ from end of post.
701	376	7	15	.00	6.60	15.60	103	203,000	1,971	Failed at knots 15″ from middle of post.
705	657	6	15	.03	8.47	16.43	139.2	279,400	2,007	Failed at knots at middle of stick.
706	437	5	15	.00	8.48	16.46	139.6	292,000	2,092	Do.
707	447	5	14	11.93	8.48	16.48	139.8	359,000	2,568	Deflected horizontally; fibers crushed near end of post.

COMPRESSION OF WHITE PINE.

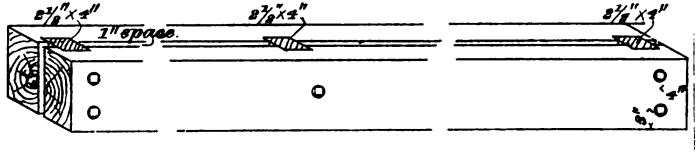
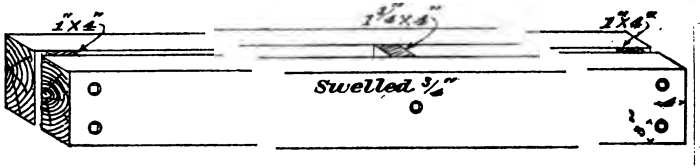
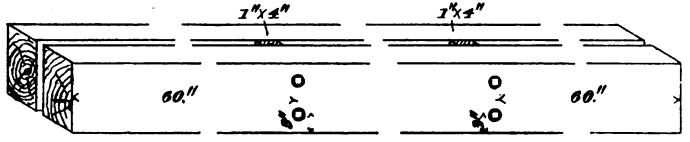
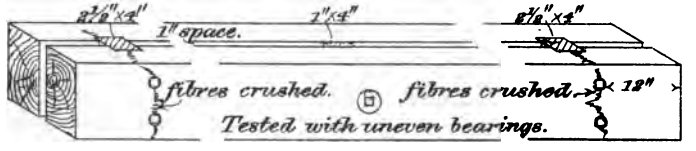
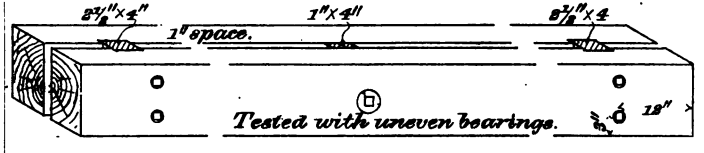
Single sticks and built posts.

TABULATED RESULTS.

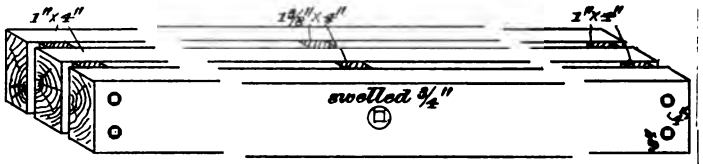
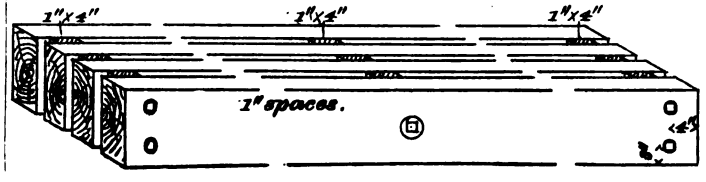
Number of test.	Kind of post.	Weight.	Average rate of growth. Rings per inch.	Dimensions of post.			Sectional area.	Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength.	
				Length.	Width.	Depth.			Actual.	Pounds per square inch.
		Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inch.*	*Pounds.*	
664		153	11	177.50	4.48	11.65	52.2	.0545	110,000	2,107
665		143	10	180	4.48	11.64	52.1	.1010	81,500	1,564
666		163	5	179.97	4.47	11.63	52.0	.0895	70,000	1,346
667		228	13	180	5.40	11.30	61.0	.0505	160,000	2,623

668		193	5	179.93	5.61	11.73	65.8	.0622	156,300	2,375
669		253	5	180	5.64	11.76	66.3	.0608	152,300	2,297
638		181 / 134 } 315	6 / 8	180 / 180	4.50 / 4.50	11.60 / 11.59	52.2 / 52.2 } 104.4	.0670 / .0750	200,000	1,916
639	Same style as No. 638	182 / 167 } 349	7 / 5	180 / 180	4.52 / 4.49	11.66 / 11.62	52.7 / 52.2 } 104.9	.0645 / .0670	212,000	2,021
640	Same style as No. 638	131 / 158 } 289	7 / 5	180 / 180	4.53 / 4.52	11.59 / 11.59	52.5 / 52.5 } 105.0	.1060 / .0955	149,000	1,419
642		192 / 306 } 498	6 / 7	179.98 / 179.98	5.57 / 5.58	11.61 / 11.61	64.7 / 64.7 } 129.4	.0770 / .0390	215,000	1,661
643	Same style as No. 642	203 / 189 } 392	17 / 5	179.92 / 179.92	5.65 / 5.61	11.61 / 11.62	65.6 / 65.2 } 130.8	.0440 / .0600	261,000	1,995
644	Same style as No. 642	227 / 236 } 463	7 / 7	179.96 / 179.96	5.60 / 5.60	11.63 / 11.62	65.1 / 65.1 } 130.2	.0596 / .0690	257,800	1,980

COMPRESSION OF WHITE PINE—Continued.

Number of test.	Kind of post.	Weight.	Average rate of growth. Rings per inch.	Dimensions of post. Length.	Width.	Depth.	Sectional area.	Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength. Actual.	Pounds per square inch.
		Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inch.*	*Pounds.*	
648		206 / 203 } 409	12 / 10	180 / 180	5.60 / 5.61	11.72 / 11.72	65.6 / 65.6 } 131.2	.0590 / .0700	268,000	2,042
649	Same style as No. 648	187 / 184 } 371	9 / 4	180 / 180	5.60 / 5.61	11.71 / 11.74	65.6 / 65.9 } 131.5	.0600 / .0705	277,000	2,107
650	Same style as No. 648	194 / 190 } 384	12 / 9	180 / 180	5.61 / 5.61	11.75 / 11.71	65.9 / 65.7 } 131.6	.0530 / .0885	240,000	1,824
645		215 / 266 } 481	5 / 7	179.97 / 179.97	5.59 / 5.60	11.59 / 11.60	64.8 / 65.0 } 129.8	.0560 / .0540	263,200	2,028
646	Same style as No. 645	206 / 204 } 410	6 / 12	180 / 180	5.59 / 5.60	11.61 / 11.62	64.9 / 65.1 } 130.0	.0493 / .0620	249,000	1,915
647	Same style as No. 645	192 / 192 } 384	11 / 13	180 / 180	5.62 / 5.62	11.62 / 11.62	65.3 / 65.3 } 130.6	.0630 / .0700	248,000	1,899

678		251 215	466	16 8	179.94 179.94	5.58 5.57	11.47 11.45	64.0 63.8	127.8	.0529 .0642	245,500	1,921
679	Same style as No. 678	209 190	399	12 7	180 180	5.62 5.62	11.76 11.72	66.1 65.9	132.0	.0664 .0705	249,000	1,886
680	Same style as No. 678	268 278	546	8 8	180 180	5.60 5.61	11.72 11.73	65.6 65.8	131.4	.0650 .0495	278,000	2,116
663		230 208	438	14 6	180 180	5.60 5.63	11.75 11.75	65.8 66.2	132.0	.0621 .0657	300,000	2,273
676		201 184	385	12 6	179.94 179.94	5.60 5.61	11.71 11.73	65.6 65.8	131.4	.0530 .0593	274,500	2,089
677	Same style of post as No. 676. Tested with uneven bearings	185 193	378	6 6	180 180	5.61 5.58	11.72 11.72	65.7 65.4	131.1	.0551 .0625	255,000	1,945
690		175 226 199	600	18 11 18	180 180 180	4.52 5.56 4.46	11.62 11.70 11.62	52.5 65.0 51.8	169.3	.0460 .0580 .0480	310,000	1,831
691	Same style as No. 690	164 197 159	520	9 14 12	179.98 179.98 179.98	4.48 5.56 4.45	11.60 11.60 11.61	52.0 64.5 51.7	168.2	.0526 .0430 .0390	372,500	2,215

COMPRESSION OF WHITE PINE—Continued.

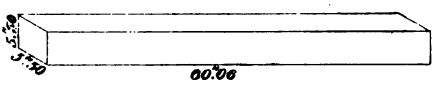
Number of test.	Kind of post.	Weight.		Average rate of growth. Rings per inch.		Dimensions of post. Length.	Width.	Depth.	Sectional area.		Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength. Actual.	Pounds per square inch.
		Pounds.				*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*		*Inch.*	*Pounds.*	
692	Same style as No. 690	248	614	13		177.25	5.62	11.60	65.2	182.2	.0580	363,000	1,992
		153		12		177.25	4.50	11.60	52.2		.0641		
		213		5		177.25	5.60	11.57	64.8		.0768		
687		151	536	11		180	4.50	11.60	52.2	169.4	.0460	325,500	1,919
		218		8		180	5.58	11.62	64.8		.0587		
		167		9		180	4.52	11.59	52.4		.0533		
688	Same style as No. 687	176	575	10		180	4.50	11.60	52.2	169.6	.0565	306,000	1,804
		236		10		180	5.62	11.60	65.2		.0645		
		163		11		180	4.50	11.60	52.2		.0703		
689	Same style as No. 687	188	550	7		180.05	4.48	11.60	52.0	168.7	.0510	340,000	2,015
		203		11		180.05	5.60	11.62	65.1		.0660		
		159		9		180.05	4.46	11.57	51.6		.0789		
681		193	688	5		179.95	4.47	11.60	51.9	209.3	.0700	363,000	1,734
		192		5		179.95	4.52	11.65	52.7		.0714		
		146		9		179.95	4.48	11.65	52.2		.0531		
		157		9		179.95	4.51	11.65	52.5		.0762		

682	Same style as No. 681	161	681	7	180	4.50	11.63	52.3	209.1	.0612	414,000	1,960
		156		14	180	4.50	11.64	52.4		.0546		
		163		7	180	4.49	11.60	52.1		.0542		
		151		9	180	4.50	11.63	52.3		.0916		
683	Same style as No. 681	169	787	10	180.03	4.46	11.63	51.9	234.9	.0570	501,000	2,133
		219		11	180.03	5.62	11.60	65.7		.0530		
		218		9	180.03	5.60	11.70	65.5		.0494		
		181		7	180.03	4.46	11.61	51.8		.0590		
684		146	756	10	180	4.50	11.64	52.4	234.6	.0664	529,000	2,255
		210		12	180	5.64	11.59	65.4		.0610		
		224		7	180	5.60	11.58	64.8		.0548		
		166		10	180	4.48	11.61	52.0		.0514		
685	Same style as No. 684	145	740	10	180	4.50	11.60	52.2	234.8	.0645	430,000	1,831
		220		10	180	5.63	11.62	65.4		.0650		
		209		12	180	5.61	11.62	65.2		.0506		
		166		9	180	4.48	11.62	52.0		.0546		
686	Same style as No. 684	145	637	11	180	4.48	11.61	52.0	207.6	.0500	395,000	1,903
		183		10	180	4.50	11.56	52.0		.0315		
		159		12	180	4.50	11.36	51.1		.0543		
		150		8	180	4.62	11.61	52.5		.0690		

1"x4"
1"x4"
1"x4"

COMPRESSION TESTS OF YELLOW-PINE POSTS.

No. 565.

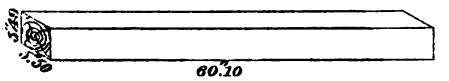


Average growth, 20 rings per inch.
Sectional area, 3.03 square inches.
Gauged length, 50″.
Weight, 47 pounds.
Not counterweighted.
Post free from knots.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,030	100	0.		
15,150	500	.0108		
	100		0.	
30,300	1,000	.0225		
	100		.0005	
45,450	1,500	.0350		
	100		.0010	
60,600	2,000	.0485		
	100		.0020	
172,000	5,677			Ultimate strength.

Crushed fibers 12″ from end.

No. 566.

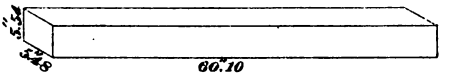


Average growth, 12 rings per inch.
Sectional area, 30.2 square inches.
Gauged length, 50″.
Weight, 44 pounds.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,020	100	0.		
15,100	500	.0126		
	100		.0002	
30,200	1,000	.0247		
	100		.0002	
45,300	1,500	.0430		
	100		.0007	
60,400	2,000	.0590		
	100		.0010	
141,000	4,669			Ultimate strength.

Failed at knots 15″ from end.

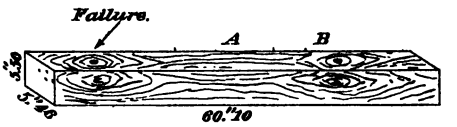
No. 567.



Sectional area, 30.4 square inches.
Gauged length, 50″.
Weight, 45 pounds.
Not counterweighted.
Average growth, 25 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,040	100	0.		
15,200	500	.0080		
	100		0.	
30,400	1,000	.0200		
	100		0.	
45,600	1,500	.0318		
	100		0.	
60,800	2,000	.0441		
	100		.0005	
168,000	5,526			Ultimate strength.

Failed at knots at 9″ and 17″ from end.



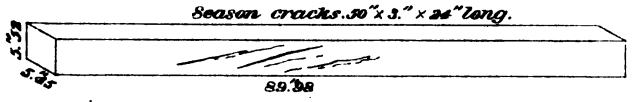
No. 568.

Sectional area, 30 square inches.
Weight, 47½ pounds.
Not counterweighted.
Post has a large knot near each end, straight-grain section between the knots.
Two gauged lengths.
Gauged length A, 15″ on straight-grain section.
Gauged length B, 10″ on section containing knot.
Average growth, 20 rings per inch.

Loads applied.	Pounds per square inch.	Compression.		Permanent set.		Remarks.
		Section A.	Section B.	Section A.	Section B.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,000	100	0.		0.		
15,000	500	.0033		.0058		
30,000	1,000	.0070		.0139		
	100		0.		.0008	
45,000	1,500	.0165		.0225		
60,000	2,000	.0140		.0315		
	100		0.		.0025	
108,000	3,600					Ultimate strength.

Failed at knot 8″ from end.

No. 562.

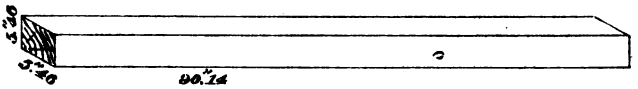


Sectional area, 30.1 square inches.
Gauged length, 50″
Weight, 72½ pounds.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
3,010	100	0.		
15,050	500	.0114		
	100		0.	
30,100	1,000	.0250		
	100		0.	
45,150	1,500	.0395		
	100		.0005	
60,200	2,000	.0537		
	100		.0010	
140,000	4,651			Ultimate strength.

Failed by opening season cracks and crushing fibers.

No. 563.

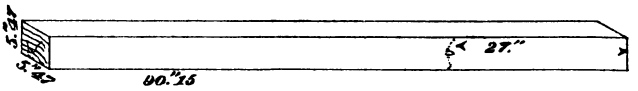


Sectional area, 29.8 square inches.
Gauged length, 50″.
Weight, 59½ pounds.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,980	100	0.		
14,900	500	.0123		
	100		0.	
29,800	1,000	.0280		
	100		.0004	
44,700	1,500	.0445		
	100		.0010	
59,600	2,000	.0621		
	100		.0021	
124,000	4,161			Ultimate strength.

Failed at some knots 30″ from end.

No. 564.

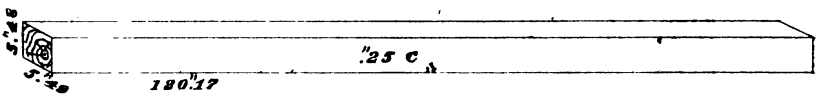


Sectional area, 29.9 square inches.
Gauged length, 50″.
Weight, 57 pounds.
Not counterweighted.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,990	100	0.		
14,950	500	.0100		
	100		0.	
29,900	1,000	.0226		
	100		.0002	
44,850	1,500	.0370		
	100		.0005	
59,800	2,000	.0512		
	100		.0009	
143,500	4,799			Ultimate strength.

Crushed fibers at knot, 27″ from end.

No. 559.

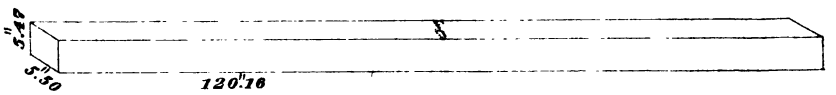


Sectional area, 30.1 square inches.
Gauged length, 100.″
Weight, 86 pounds.
Not counterweighted.
Initial deflection before dressed from size 6″×6″: Horizontal, ″.25.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,010	100	0.		0.	0.	
15,050	500	.0190		0.	0.	
	100		0.	0.	0.	
30,100	1,000	.0440		0.	.01	
	100		0.	0.	0.	
45,150	1,500	.0700		0.	.01	
	100		.0002	0.	0.	
60,200	2,000	.0964		0.	.01	
	100		.0010	0.	0.	
80,000				0.	.01	
100,000				0.	.01	
120,000				.02	.01	
140,000				.07	.04	
146,200	4,857			.15	.15	Ultimate strength.

Failed by deflecting upwards, crushing fibers in the vicinity of knots at middle of post.

No. 560.

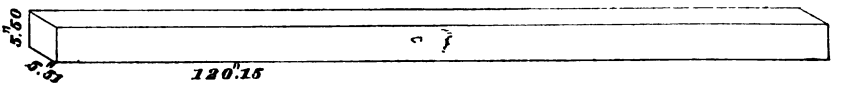


Sectional area, 30.1 square inches.
Gauged length, 100″.
Weight, 88½ pounds.
Not counterweighted.
Cross-grained stick with season cracks.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,010	100	0.	.....	0.	0.	
15,050	500	.0207	.....	—.01	—.03	
.....	100	.....	.0010	0.	0.	
30,100	1,000	.0480	.....	—.04	—.10	
.....	100	.....	.0010	.....	.....	
45,150	1,500	.0750	.....	—.06	—.16	
.....	100	.....	.0018	0.	0	
60,200	2,000	.1030	.....	—.06	—.21	
.....	100	.....	.0025	0.	0.	
70,000	.....	.....	.....	—.07	—.28	
80,000	.....	.....	.....	—.07	—.34	
90,000	.....	.....	.....	—.06	—.40	
100,000	.....	.....	.....	—.05	—.46	
110,000	.....	.....	.....	—.05	—.46	
120,000	.....	.....	.....	.....	—.70	
130,000	.....	.....	.....	.....	—.90	
139,000	4,618	.....	.....	.....	.....	Ultimate strength.

Failed, crushing fibers at knot at middle of post; deflected downward.

No. 561.

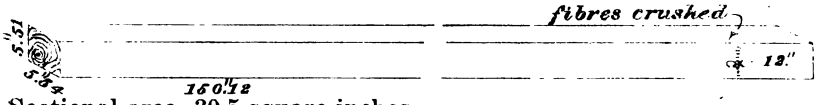


Sectional area, 30.3 square inches.
Gauged length, 100″.
Weight, 110 pounds.
Not counterweighted.
Worm-eaten post.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,030	100	0.	.....	0.	0.	
15,150	500	.0164	.....	—.01	0.	
.....	100	.....	0.	0.	0.	
30,300	1,000	.0385	.....	—.01	0.	
.....	100	.....	0.	0.	0.	
45,450	1,500	.0600	.....	—.02	—.02	
.....	100	.....	0.	0.	0.	
60,600	2,000	.0820	.....	—.02	—.04	
.....	100	.....	.0010	0.	0.	
70,000	.....	.....	.....	—.02	—.05	
80,000	.....	.....	.....	—.04	—.06	
90,000	.....	.....	.....	—.05	—.07	
100,000	.....	.....	.....	—.05	—.09	
110,000	.....	.....	.....	—.05	—.10	
120,000	.....	.....	.....	—.06	—.11	
130,000	.....	.....	.....	—.07	—.12	
140,000	.....	.....	.....	—.10	—.13	
143,600	4,739	.....	.....	.....	.....	Ultimate strength.

Failed by crushing fibers in vicinity of knot at middle of post.

No. 556.

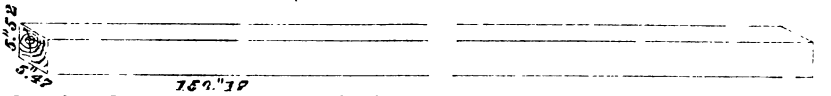


Sectional area, 30.5 square inches.
Weight, 126 pounds.
Gauged length, 100″.
Counterweight at middle, 64 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,050	100	0.		0.	0.	
15,250	500	.0190		.01	0.	
	100		0.	0.	0.	
30,500	1,000	.0438		.03	0.	
	100		−.0006	0.	0.	
45,550	1,500	.0680		.05	0.	
	100		.0004	0.	0.	
61,000	2,000	.0932		.08	0.	
	100		.0002	0.	0.	
70,000				.09	0.	
80,000				.11	0.	
90,000				.14	0.	
100,000				.16	0.	
110,000				.19	0.	
120,000				.23	0.	
130,000				.28	−.02	
140,000				.35	−.05	
150,000				.49	−.11	
156,000	5,114			.85	−.11	Ultimate strength.

Failed by deflection sideways. Crushed fibers at knot 12″ from end of post.

No. 557.

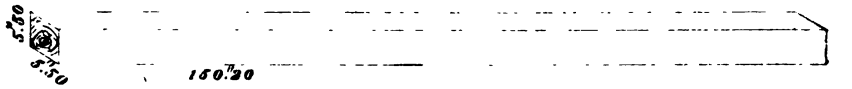


Sectional area, 30.2 square inches.
Gauged length, 100″.
Weight, 128 pounds.
Counterweight at middle, 64 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,020	100	0.		0.	0.	
15,100	500	.0166		0.	0.	
	100		0.	0.	0.	
30,200	1,000	.0386		0.	0.	
	100		.0007	0.	0.	
45,300	1,500	.0610		−.02	−.01	
	100		.0009	0.	0	
60,400	2,000	.0840		−.04	−.03	
	100		.0010	0.	0.	
70,000				−.05	−.04	
80,000				−.06	−.06	
100,000				−.10	−.10	
110,000				−.11	−.11	
120,000				−.14	−.13	
130,000				−.18	−.16	
140,000				−.24	−.20	
150,000				−.34	−.29	
156,000	5,166			−.70	−.50	Ultimate strength.

Failed by deflecting diagonally downward and sideways.

No. 558.

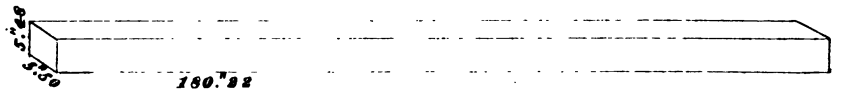


Sectional area, 30.3 square inches.
Gauged length, 100″.
Weight, 141½ pounds.
Counterweight at middle, 64 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,030	100	0.		0.	0.	
15,150	500	.0172		— .07	0.	
	100		0.	0.	0.	
30,300	1,000	.0400		— .12	0.	
	100		— .0004	— .01	0.	
45,450	1,500	.0629		— .17	0.	
	100		— .0003	— .01	0.	
60,600	2,000	.0865		— .19	— .02	
	100		— .0002	— .01	0.	
70,000				— .21	— .04	
80,000				— .22	— .05	
90,000				— .25	— .06	
100,000				— .27	— .08	
110,000				— .29	— .09	
120,000				— .31	— .10	
130,000				— .36	— .11	
140,000				— .40	— .12	
150,000	4,950			— .66	— .12	Ultimate strength.

Failed by deflecting sideways and upwards, changing the direction of the vertical deflections after passing the maximum load.

No. 553.



Sectional area, 30.1 square inches.
Weight, 140 pounds.
Gauged length, 100″.
Counterweight at middle, 64 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,010	100	0.		0.	0.	
15,050	500	.0230		.01	.04	
	100		.0002	0.	0.	
30,100	1,000	.0552		.01	.05	
	100		0.	0.	.01	
40,000				+ .02	.06	
50,000				+ .02	.07	
60,000				+ .02	.07	
70,000				.04	.04	
80,000				.05	0.	
90,000				.08	— .10	
99,200	3,296			.27	— .80	Ultimate strength.

Failed by deflecting downward.

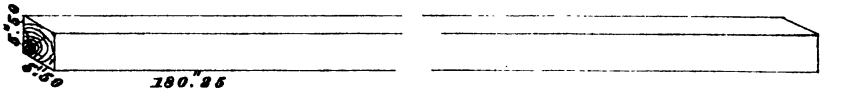
No. 554.

Sectional area, 30 square inches.
Gauged length, 100″.
Weight, 148 pounds.
Counterweight at middle, 76 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,000	100	0.		.03	.03	
15,000	500	.0189		.03	.03	
	100		0.	.03	.03	
30,000	1,000	.0435		.03	.01	
	100		0.	.03	.03	
45,000	1,500	.0688		.03	0.	
	100		.0002	.03	.03	
60,000	2,000	.0935		.04	— .02	
	100		0.	.03	.03	
70,000				.05	— .02	
80,000				.07	— .03	
90,000				.07	— .04	
100,000				.10	— .06	
110,000				.13	— .07	
120,000				.20	— .08	
130,000	4,333			.52	— .02	Ultimate strength.

Failed by deflecting sideways, reversing the vertical deflections and bending upward slightly.

No. 555.

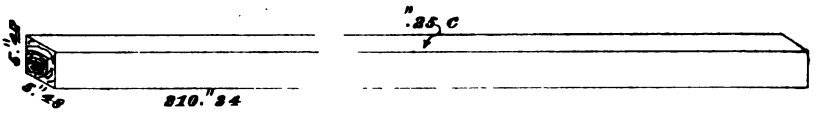


Sectional area, 30.3 square inches.
Gauged length, 100″.
Weight, 148 pounds.
Counterweight at middle, 76 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
3,030	100	0.		0.	0.	
15,150	500	.0200		— .02	— .01	
	100		0.	0.	0.	
30,300	1,000	.0450		— .05	— .02	
	100		0.	0.	0.	
45,450	1,500	.0706		— .05	— .02	
	100		.0011	— .01	0.	
60,600	2,000	.0970		— .06	— .02	
	100		.0016	— .01	0.	
70,000				— .07	— .02	
80,000				— .07	— .02	
90,000				— .07	— .03	
100,000				— .08	— .04	
110,000				— .11	— .06	
120,000				— .16	— .09	
129,000	4,257			— .50	— .30	Ultimate strength.

Failed by deflecting diagonally downward and sideways.

No. 550.

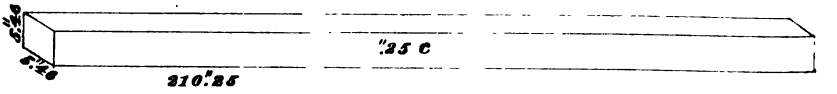


Sectional area, 30 square inches.
Weight, 172 pounds.
Counterweight at middle, 88 pounds.
Initial deflection before stick was dressed down from size 6″ × 6″: Vertical, — ″.25.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
2,000				— .06	— .08	
4,000				— .06	— .06	
6,000				— .06	— .05	
8,000				— .06	— .04	
10,000				— .06	— .02	
14,000				— .06	— .01	
18,000				— .07	0.	
20,000				— .08	0.	
22,000				— .09	0.	
26,000				— .10	0.	
30,000				— .10	0.	
34,000				— .11	0.	
38,000				— .13	0.	
40,000				— .15	0.	
50,000				— .20	0.	
60,000				— .26	0.	
70,000				— .35	0.	
80,000				— .51	— .01	
90,000	3,000			—1.03	— .06	Ultimate strength.

Failed suddenly under the maximum load, deflecting sideways, splitting the stick at the middle where it was cross-grained.

No. 551.



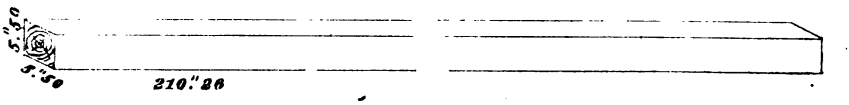
Sectional area, 29.8 square inches.
Weight, 180½ pounds.
Counterweight at middle, 88 pounds.
Initial deflection before stick was dressed down from size 6″ × 6″: Horizontal, ″.25.

Loads applied.	Pounds per square inch.	Deflections.		Remarks.
		Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	
2,000		.09	.09	
4,000		.09	.09	
6,000		.10	.09	
8,000		.10	.09	
10,000		.10	.09	
14,000		.11	.09	

Loads applied.	Pounds per square inch.	Deflections.		Remarks.
		Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	
18,000	.....	.11	.09	
22,000	.....	.12	.09	
26,000	.....	.13	.09	
30,000	.....	.14	.09	
40,000	.....	.17	.09	
50,000	.....	.21	.10	
60,000	.....	.26	.10	
70,000	.....	.33	.11	
80,000	.....	.45	.12	
90,000	.....	.60	.14	
100,000	.....	.89	.20	
109,000	3 658	1.95	.50	Ultimate strength.

Deflected sideways.

No. 552.

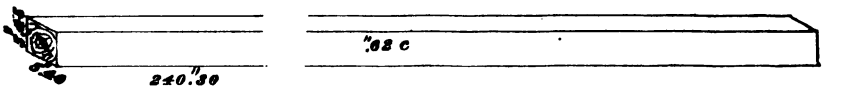


Sectional area, 30.3 square inches.
Weight, 167½ pounds.
Counterweight at middle, 88 pounds.

Loads applied.	Pounds per square inch.	Deflections.		Remarks.
		Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	
2,000	.....	0.	0.	
4,000	.....	0.	0.	
6,000	.....	0.	0.	
8,000	.....	0.	0.	
10,000	.....	0.	0.	
14,000	.....	—.01	0.	
18,000	.....	—.01	0.	
22,000	.....	—.02	.01	
26,000	.....	—.03	.01	
30,000	.....	—.03	.01	
40,000	.....	—.05	.01	
50,000	.....	—.06	.01	
60,000	.....	—.09	.01	
70,000	.....	—.14	.01	
80,000	.....	—.25	.01	
90,000	.....	—.52	.01	
93,000	3,069	—1.42	.01	Ultimate strength.

Deflected horizontally.

No. 548.

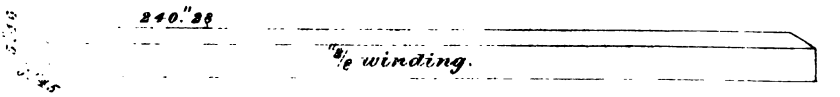


Sectional area, 29.4 square inches.
Weight, 185 pounds.
Counterweight at middle, 88 pounds.
Initial deflection before stick was dressed down from size 6″×6″: Horizontal, + ″.62.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		0.	0.	
4,000		—.05	.01	
6,000		—.07	.02	
8,000		—.08	.02	
10,000		—.09	.02	
14,000		—.10	.02	
18,000		—.11	.02	
22,000		—.13	.02	
26,000		—.15	.02	
30,008		—.17	.02	
34,000		—.19	.02	
38,000		—.20	.01	
42,000		—.23	.01	
46,000		—.25	0.	
50,000		—.30	0.	
54,000		—.32	0.	
56,000		—.35	0.	
58,000		—.36	0.	
62,000		—.40	0.	
66,000		—.50	0.	
70,000		—.60	0.	
74,000		—.75	0.	
78,000		—1.00	.05	
80,000		—1.28	.08	
82,000	2,789			Ultimate strength.

Failed by deflecting sideways.

No. 549.

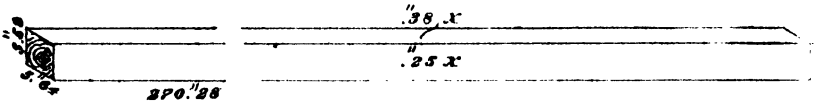


Sectional area, 29.8 square inches.
Weight, 185 pounds.
Counterweight at middle, 88 pounds.
Post was $\frac{3}{8}$″ winding before dressed down from size 6″×6″.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		—.04	—.06	
4,000		—.05	—.08	
6,000		—.05	—.10	
8,000		—.05	—.11	
10,000		—.05	—.12	
14,000		—.05	—.13	
18,000		—.05	—.14	
22,000		—.06	—.15	
26,000		—.06	—.16	
30,000		—.07	—.18	
40,000		—.09	—.22	
50,000		—.11	—.29	
54,000		—.16	—.40	
66,000		—.18	—.41	
68,000		—.20	—.43	
70,000		—.21	—.48	
72,000		—.22	—.52	
74,000		—.25	—.58	
76,000		—.26	—.61	
78,000		—.30	—.67	
80,000		—.34	—.75	
82,000		—.37	—.83	
84,000		—.45	—.96	
86,000		—.56	—1.13	
87,800	2,946	—.97	—1.59	Ultimate strength.

Deflected downward and sideways.

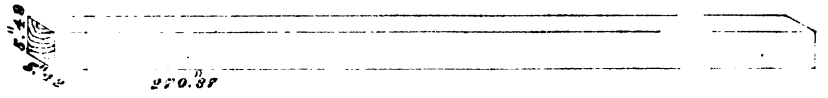
No. 545.



Sectional area, 31.5 square inches.
Weight, 212 pounds.
Counterweight at middle, 108 pounds.
Initial deflections before stick was dressed down from size 6″×6″: Horizontal, −″.25; vertical, +″.38.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		−.10	0.	
4,000		−.10	0.	
6,000		−.10	0.	
8,000		−.10	.01	
10,000		−.11	.01	
12,000		−.11	.01	
16,000		−.12	.01	
20,000		−.15	.02	
24,000		−.16	.02	
28,000		−.18	.03	
30,000		−.20	.03	
32,000		−.20	.04	
34,000		−.22	.04	
36,000		−.23	.04	
38,000		−.25	.05	
40,000		−.27	.06	
42,000		−.28	.07	
44,000		−.30	.08	
46,000		−.32	.09	
48,000		−.34	.10	
50,000		−.36	.11	
52,000		−.38	.12	
54,000		−.40	.13	
56,000		−.45	.14	
58,000		−.49	.16	
60,000		−.54	.19	
62,000		−.60	.21	
64,000		−.68	.25	
66,000		−.75	.30	
68,000		−.86	.34	
70,000		−1.00	.43	
73,700	2,340	−1.75	.90	Ultimate strength.
		−2.80	1.80	Sudden spring when deflection reached this amount, sustaining about 60,000 pounds at the time.

No. 546.

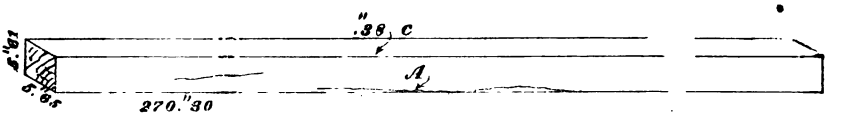


Sectional area, 29.8 square inches.
Weight, 189 pounds.
Counterweight at middle, 96 pounds.
This stick was ¾″ winding before dressing down from size 6″×6″.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		.04	0.	
4,000		.07	.03	
6,000		.09	.06	
8,000		.09	.08	
10,000		.09	.09	
14,000		.09	.11	
18,000		.09	.13	
22,000		.09	.16	
26,000		.09	.19	
30,000		.09	.22	
34,000		.09	.26	
38,000		.09	.31	
42,000		.06	.37	
46,000		.03	.47	
50,000		− .02	.65	
54,000		− .16	.98	
56,000	1,879	− .50		Ultimate strength.

Failed by vertical deflection.

No. 547.



Sectional area, 31.7 square inches.

Weight, 266 pounds.

Counterweight at middle, 140 pounds.

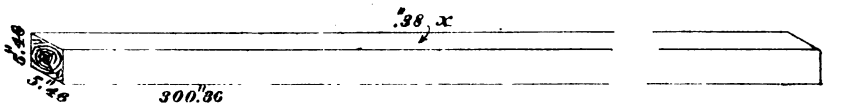
Initial deflection before stick was dressed down from size 6″ × 6″: Vertical, −″.38.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		− .20	− .14	
4,000		− .20	− .12	
6,000		− .20	− .10	
8,000		− .20	− .10	
10,000		− .20	− .09	
14,000		− .20	− .09	
18,000		− .20	− .10	
22,000		− .20	− .10	
26,000		− .21	− .10	
30,000		− .21	− .10	
34,000		− .22	− .10	
38,000		− .22	− .10	
42,000		− .25	− .10	
46,000		− .26	− .10	Snapping sounds.
50,000		− .27	− .10	
54,000		− .30	− .11	
58,000		− .27	− .15	
62,000		− .20	− .15	
62,500	1,972			Ultimate strength.

Failed by deflecting sideways in plus direction and upwards.

Before the maximum load was reached, crack at A opened on the convex side corner about ½ square inch, splintering partly off, forming a loop. At the time of maximum load this splinter broke by compression and at the same time the deflections were reversed, changing from minus to plus directions, the splintering corner now being on the concave side.

No. 508.



Sectional area, 29.9 square inches.
Weight, 210 pounds.
Counterweight at middle, 105 pounds.
Initial deflection before dressing down from size 6″×6″: Vertical, +″.38.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000	.....	+ .18	+ .12	
4,000	.....	+ .18	+ .12	
6,000	.....	+ .18	+ .12	
8,000	.....	+ .18	+ .12	
10,000	.....	+ .18	+ .12	
12,000	.....	.20	+ .12	
14,000	.....	.21	+ .12	
16,000	.....	.22	+ .12	
18,000	.....	.24	.13	
20,000	.....	.25	.14	
22,000	.....	.29	.15	
24,000	.....	.30	.17	
26,000	.....	.33	.18	
28,000	.....	.36	.18	
30,000	.....	.40	.19	
32,000	.....	.45	.20	
34,000	.....	.50	.20	
36,000	.....	.55	.22	
38,000	.....	.59	.23	
40,000	.....	.67	.25	
42,000	.....	.76	.27	
44,000	.....	.89	.30	
45,000	.....	.97	.32	Snapping sounds.
46,000	.....	1.06	.33	
47,000	.....	1.17	.35	
48,000	.....	1.30	.38	
49,000	.....	1.45	.40	
50,000	.....	1.68	.44	
51,000	.....	1.95	.50	
52,000	1,739	2.40	.56	Ultimate strength.

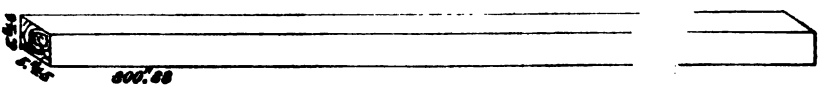
Failed by deflecting sideways and upward.

No. 509.

Sectional area, 30 square inches.
Weight, 235 pounds.
Counterweight at middle, 117 pounds.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		−.08	0.	
4,000		−.12	0.	
6,000		−.14	.01	
8,000		−.15	.02	
10,000		−.17	.02	
12,000		−.18	.03	
14,000		−.18	.04	
16,000		−.18	.05	
18,000		−.18	.05	
20,000		−.19	.05	
22,000		−.20	.06	
24,000		−.20	.06	
26,000		−.21	.07	
28,000		−.22	.08	
30,000		−.23	.09	
32,000		−.25	.10	
34,000		−.26	.10	
36,000		−.28	.10	
38,000		−.30	.11	
40,000		−.32	.11	
42,000		−.34	.11	
44,000		−.36	.11	
46,000		−.40	.11	
48,000		−.45	.11	
50,000		−.51	.11	
52,000		−.64	.12	
54,000		−.78	.12	
56,000		−1.00	.12	
58,000		−1.48	.12	
59,000	1,967	−2.12	.11	Ultimate strength.

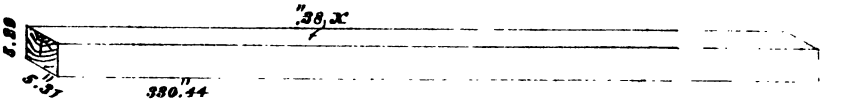
No. 510.



Sectional area, 29.8 square inches.
Weight, 210 pounds.
Counterweight at middle, 105 pounds.
Post ".38 winding before dressing down from size 6″ × 6″.

Loads applied	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		−.04	+.05	
4,000		−.01	+.05	
6,000		0.	.04	
8,000		0.	.02	
10,000		0.	0.	
12,000		0.	0.	
14,000		0.	0.	
16,000		+.01	−.02	
18,000		.02	−.04	
20,000		.02	−.05	
22,000		.03	−.06	
24,000		.04	−.07	
26,000		.06	−.08	
28,000		.08	−.09	
30,000		.10	−.10	
32,000		.12	−.11	
34,000		.13	−.12	
36,000		.15	−.13	
38,000		.18	−.15	
40,000		.22	−.16	
42,000		.26	−.17	
44,000		.30	−.18	
46,000		.40	−.20	
48,000		.50	−.20	
50,000		.63	−.20	
51,000		.75	−.20	
53,000		1.05	−.21	
54,000		1.38	−.21	
55,000		1.63	−.20	
55,500	1,862			Ultimate strength.

No. 499.



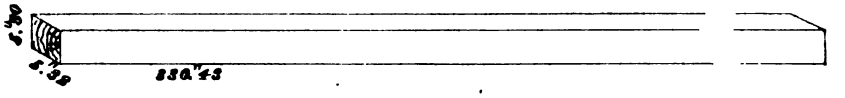
Sectional area, 28.1 square inches.
Weight, 258 pounds.
Counterweight at middle, 129 pounds.
Initial bend in post before dressing down from size 3″×6″: Vertical, +″.38.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		0.	+ .30	
3,000		0.	.30	
4,000		— .02	.24	
5,000		— .05	.20	
6,000		— .08	.16	
7,000		— .08	.15	
8,000		— .08	.13	
9,000		— .07	.12	
10,000		— .07	.10	
11,000		— .07	.10	
12,000		— .08	.10	
13,000		— .08	.10	
14,000		— .08	.10	
15,000		— .08	.08	
16,000		— .08	.08	
17,000		— .08	.08	
18,000		— .08	.08	
19,000		— .08	.08	
20,000		— .08	.08	
21,000		— .08	.08	
22,000		— .08	.08	
23,000		— .08	.08	
24,000		— .08	.08	
25,000		— .08	.08	
26,000		— .08	.08	
27,000		— .08	.07	
28,000		— .08	.07	
29,000		— .08	.06	
30,000		— .08	.06	
31,000		— .08	.06	
32,000		— .06	.05	
33,000		— .06	.05	
34,000		— .06	.05	
35,000		— .05	.05	
36,000		— .04	.05	
37,000		— .04	.05	
38,000		— .02	.05	
39,000		— .02	.05	
40,000		— .02	.04	
41,000		— .02	.04	
42,000		0	.04	
43,000		0	.04	
44,000		0	.03	
45,000		0	.02	
46,000		+ .02	.01	
47,000		.05	.01	
48,000		.06	0.	
49,000		.08	0.	
50,000		.10	0.	
51,000		.12	0.	
52,000		.15	0.	
53,000		.19	0.	
54,000		.21	0.	
55,000		.27	0.	
56,000		.32	0.	
57,000		.44	0.	
58,000		.55	0.	
59,000		.72	— .03	
60,000		1.00	— .03	
60,800	2,163	2.00	— .03	Ultimate strength.

Failed by horizontal deflection, suddenly springing when the maximum load was reached, increasing the horizontal deflection to about 8″. Load released to 10,000 pounds and maximum loads repeated, sudden springing occurring when the following loads were reached: 56,000, 54,000, and 53,000 pounds.

Between each loading, strains were released to 10,000 pounds.

No. 500.



Sectional area, 28.2 square inches.

Weight, 236 pounds.

Counterweight at middle, 118 pounds.

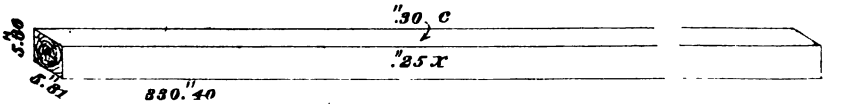
Initial bend before dressing down from 6″×6″ stick: Horizontal, —″.38; post winding, ″.38.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		—.50	—.12	
4,000		—.45	—.12	
6,000		—.45	—.12	
8,000		—.45	—.12	
10,000		—.48	—.12	
12,000		—.50	—.17	
14,000		—.62	—.19	
16,000		—.56	—.20	
18,000		—.59	—.22	
20,000		—.62	—.25	
22,000		—.68	—.23	
24,000		—.74	—.30	
26,000		—.80	—.32	
28,000		—.90	—.37	Figures below refer to this curved line:
30,000		—1.00	—.40	
31,000		—1.05	—.45	
32,000		—1.13	—.50	
33,000		—1.20	—.53	
34,000		—1.30	—.56	
35,000		—1.40	—.60	Shape of stick while under 38,000 pounds compression. Ordinates measured each 2 feet.
36,000		—1.55	—.66	
37,000		—1.70	—.70	
38,000		—1.95	—.79	0, ″.28, ″.65, 1″.10, 1″.55, 1″.85, 2″.05, 2″.06, 1″.88, 1″.57, 1″.15, ″.70, ″.32, ″.15, ″.18, 0.
38,000		—2.18	—.92	
39,000	1,383	—2.70	—1.07	Ultimate strength.

Failed by horizontal and downward deflection. Deflected suddenly when load reached its maximum, increasing to about 8″ horizontal and vertical at middle.

Posts of this length and diameter have changed from triple flexure when sudden springing occurred to single flexure, like a post with pin ends.

No. 501.



Sectional area, 28.1 square inches.

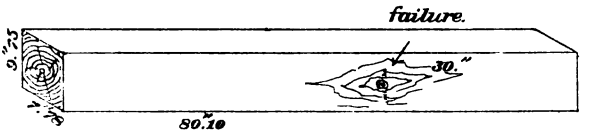
Weight, 256 pounds.

Counterweight at middle, 128 pounds.
Initial bend to stick before dressed down from size 6″×6″: Horizontal, —″.25; vertical, —″.30.

Loads applied.	Pounds per square inch.	Deflections. Horizontal.	Deflections. Vertical.	Remarks.
Pounds.		*Inch.*	*Inch.*	
2,000		—.27	—.40	
4,000		—.27	—.22	
6,000		—.26	—.09	
8,000		—.27	—.04	
10,000		—.28	—.03	
12,000		—.29	—.01	
14,000		—.30	0.	
16,000		—.31	.01	
18,000		—.32	.02	
20,000		—.35	.04	
22,000		—.38	.05	
24,000		—.38	.06	
26,000		—.42	.07	
28,000		—.47	.08	
30,000		—.51	.10	
32,000		—.56	.11	
34,000		—.65	.12	
36,000		—.75	.15	
38,000		—.90	.16	
40,000		—1.10	.20	
42,000		—1.40	.26	
43,000		—1.70	.32	
44,000		—2.10	.42	
44,400	1,580			Ultimate strength.

Failed by deflection sideways and upward, springing suddenly soon after passing the maximum load, increasing the deflections to about —8″ horizontal, 2″ vertical.

No. 572.

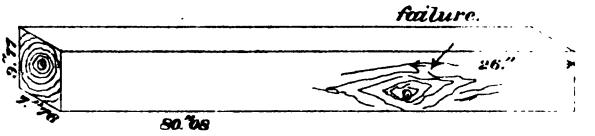


Sectional area, 75.8 square inches.
Weight, 124 pounds.
Gauged length, 50″.
Not counterweighted.
Average growth, 6 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,580	100	0.		
37,900	500	.0210		
	100		.0004	
75,800	1,000	.0460		
	100		.0011	
113,700	1,500	.0716		
	100		.0029	
151,600	2,000	.0994		
	100		.0055	
260,000	3,430			Ultimate strength.

Failed at a knot 2″ diameter, 30″ from end of post.

No. 573.

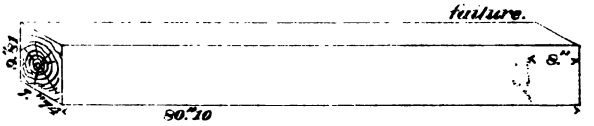


Sectional area, 75.8 square inches.
Weight, 131 pounds.
Gauged length, 50″.
Not counterweighted.
Average rate of growth, 14 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,580	100	0.		
37,900	500	.0113		
	100		0.	
75,800	1,000	.0270		
	100		.0005	
113,700	1,500	.0436		
	100		.0009	
151,600	2,000	.0595		
	100		.0012	
286,500	3,780			Ultimate strength.

Failed by crushing fibers at a knot 26″ from end of post.

No. 574.

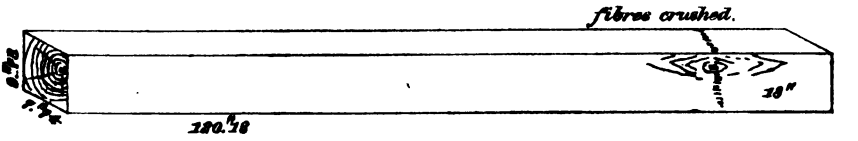


Sectional area, 75.9 square inches.
Weight, 161½ pounds.
Gauged length, 50″.
Not counterweighted.
Average rate of growth, 21 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,590	100	0.		
37,950	500	.0110		
	100		0.	
75,900	1,000	.0245		
100			.0003	
113,850	1,500	.0390		
	100		.0008	
151,800	2,000	.0530		
	100		.0010	
383,000				Ultimate strength.

Fibers crushed about 8″ from end, in the vicinity of knots.

No. 578.

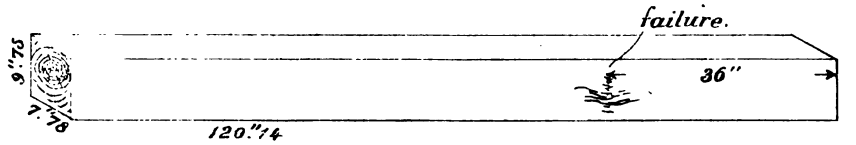


Sectional area, 75.3 square inches.
Weight, 233½ pounds.
Gauged length, 100″.
Not counterweighted.
Average rate of growth, 23 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,530	100	0.		
37,650	500	.0230		
	100		.0007	
75,300	1,000	.0530		
	100		.0011	
112,950	1,500	.0830		
	100		.0018	
150,600	2,000	.1147		
	100		.0027	
304,000	4,037			Ultimate strength.

Failed at a knot 18″ from end of post.

No. 579.

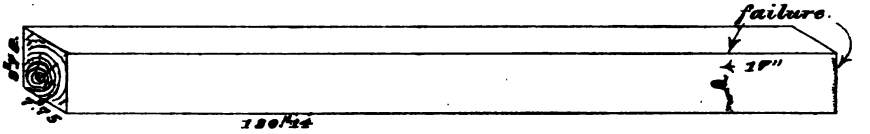


Sectional area, 75.9 square inches.
Weight, 240 pounds.
Gauged length, 100″.
Not counterweighted.
Average growth, 19 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,590	100	0.		
37,950	500	.0160		
	100		.0005	
75,900	1,000	.0375		
	100		.0008	
113,850	1,500	.0604		
	100		.0010	
151,800	2,000	.0840		
	100		.0010	
399,500	5,264			Ultimate strength.

Crushed fibers 36″ from end. Grain of the wood wavy at this place.

No. 580.

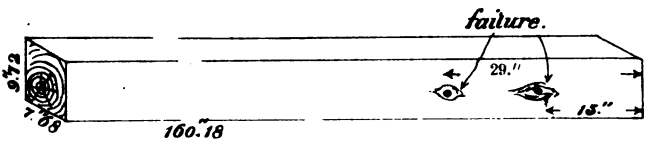


Sectional area, 75.6 square inches.
Weight, 240 pounds.
Gauged length, 100″.
Not counterweighted.
Average rate of growth, 28 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,560	100	0.		
37,800	500	.0175		
	100		0.	
75,600	1,000	.0415		
	100		0.	
113,400	1,500	.0663		
	100		0.	
151,200	2,000	.0913		
	100		0.	
350,000	4,629			Ultimate strength.

Crushed fibers at end of post and at knot 17″ from end.

No. 584.

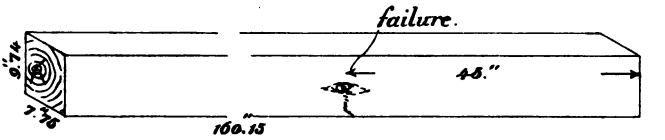


Sectional area, 74.6 square inches.
Weight, 266 pounds.
Gauged length, 100″.
Not counterweighted.
Average rate of growth, 18 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,460	100	0.		
37,300	500	.0182		
	100		.0010	
74,600	1,000	.0465		
	100		.0017	
111,900	1,500	.0758		
	100			
149,200	2,000	.1080		
	100		.0035	
307,500	4,122			Ultimate strength.

Failed at knots 15″ and 29″ from end.

No. 585.

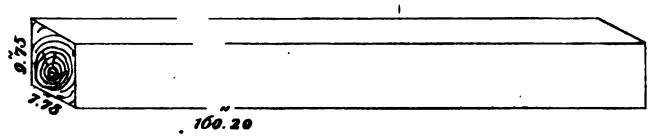


Sectional area, 75.5 square inches.
Gauged length, 100″.
Weight, 258 pounds.
Not counterweighted.
Average rate of growth, 6 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,550	100	0.		
37,750	500	.0287		
	100		0.	
75,500	1,000	.0700		
	100		.0006	
113,250	1,500	.1135		
	100		.0025	
151,000	2,000	.1600		
	100		.0061	
284,000	3,762			Ultimate strength.

Fibers crushed at knots 45″ from end and near the middle.
Post deflecting downward.

No. 586.

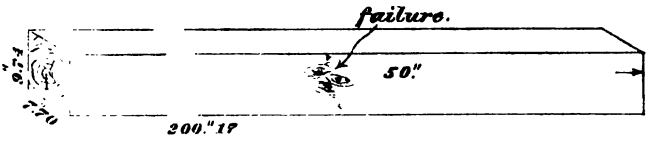


Sectional area, 75.5 square inches.
Weight, 336 pounds.
Gauged length, 100″.
Not counterweighted.
Average rate of growth, 23 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
7,560	100	0.		
37,800	500	.0220		
	100		0.	
75,600	1,000	.0525		
	100		.0002	
113,400	1,500	.0835		
	100		.0008	
151,200	2,000	.1150		
	100		.0015	
296,000	3,921			Ultimate strength.

Fibers crushed at knot near middle of post.

No. 587.

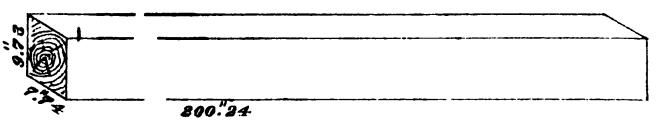


Sectional area, 75 square inches.
Gauged length, 150".
Weight, 318 pounds.
Counterweight at middle, 158 pounds.
Average rate of growth, 24 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,500	100	0.		0.	0.	
37,500	500	.0375		0.	.05	
	100		0.	0.	0.	
75,000	1,000	.0900		0.	.06	
	100		0.	0.	0.	
112,500	1,500	.1450		0.	.08	
	100		.0020	0.	0.	
150,000	2,000	.2015		0.	.11	
	100		.0055	0.	.01	
200,000				0.	.17	
250,000				.10	.20	
74,500	3,660			.70	.25	Ultimate strength.

Failed at a group of knots 50" from end, maximum deflection at this point.

No. 588.

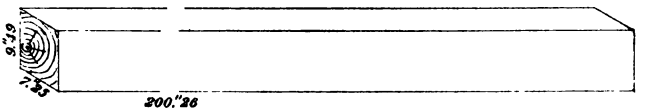


Sectional area, 75.3 square inches.
Gauged length, 150".
Weight, 381 pounds.
Counterweight at middle, 190 pounds.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,530	100	0.	.....	0.	0.	This post is free from knots; straight grain.
37,650	500	.0330	.....	0.	—.02	
.....	100	.....	.0011	0.	0.	
75,300	1,000	.0730	.....	0.	—.04	
.....	100	.....	.0020	0.	0.	
112,950	1,500	.1125	.....	0.	—.07	
.....	100	.....	.0030	0.	0.	
150,600	2,000	.1520	.....	0.	—.07	
.....	100	.....	.0040	0.	0.	
200,000	.....	.....	.....	.02	—.09	
250,000	.....	.....	.....	.04	—.10	
300,000	.....	.....	.....	.08	—.12	
350,000	.....	.....	.....	.15	—.17	
382,000	5,073	.....	.....	.....	.....	Ultimate strength.

Failed by deflecting sideways.

No. 589.

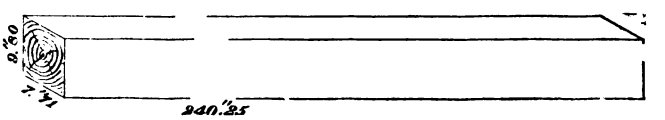


Sectional area, 68.8 square inches.
Gauged length, 150″.
Weight, 339½ pounds.
Counterweight at middle, 170 pounds.
Average rate of growth, 21 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,880	100	0.	.....	0.	0.	Season cracks in post running diagonally.
34,400	500	.0365	.....	0.	0.	
.....	100	.....	.0016	0.	0.	
68,800	1,000	.0800	.....	.01	.03	
.....	100	.....	.0025	0.	0.	
103,200	1,500	.1240	.....	.03	.06	
.....	100	.....	.0035	0.	0.	
137,600	2,000	.1688	.....	.04	.10	
.....	100	.....	.0050	0.	0.	
250,000	.....	.....	.....	.08	.20	
300,000	.....	.....	.....	—.15	.24	
304,000	4,419	.....	.....	—.50	.23	Ultimate strength.

Failed by deflecting sideways.

No. 530.

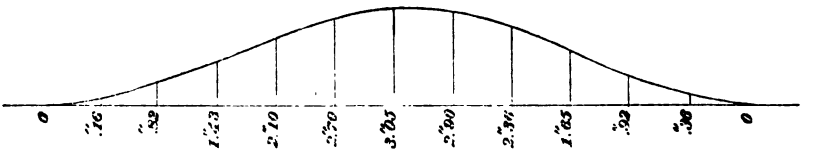


Sectional area, 75.6 square inches.
Gauged length, 200″.

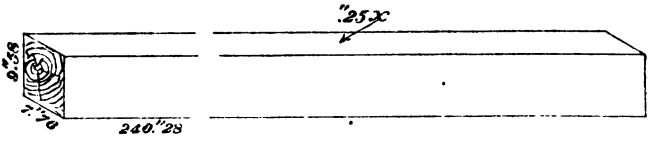
Weight, 461 pounds.
Counterweight at middle, 225 pounds.
Straight-grained, free from knots.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7, 560	100	0.		0.	0.	
37, 800	500	.0422		.01	.01	
	100		0.	0.	0.	
75, 600	1, 000	.0958		.04	.03	
	100		.0009	0.	0.	
113, 400	1, 500	.1515		.09	.05	
	100		.0012	0.	0.	
151, 200	2, 000			.14	.07	
160, 000				.15	.08	
170, 000				.17	.10	
180, 000				.19	.10	
189, 000	2, 500			.20	.10	
200, 000				.22	.11	
210, 000				.25	.12	
220, 000				.28	.12	
230, 000				.32	.13	
240, 000				.35	.14	
250, 000				.41	.15	
260, 000				.49	.16	
270, 000				.65	.19	
280, 000				.95	.24	
287, 000	3, 796			1.60	.24	Ultimate strength.

Failed by horizontal deflection.
Strains continued, increasing the deflection to 3″.05 at middle. Ordinates now measured each 20″ to show the curve of flexure.



No. 531.

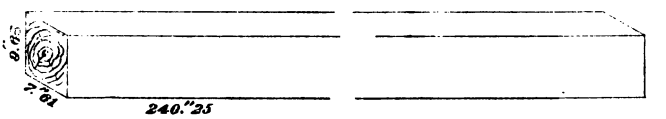


Sectional area, 74.3 square inches.
Gauged length, 200″.
Weight, 410 pounds.
Counterweight at middle, 225 pounds.
Post has 18 knots from $\frac{3}{4}$″ to 2″ diameter. Initial bend in stick before dressing down from size 8″ × 10″: Vertical, +″.25.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,430	100	0.	.....	0.	0.	
37,150	500	.0510	.....	0.	—.03	
.....	100	.....	.0005	0.	0.	
74,300	1,000	.1095	.....	.01	—.04	
.....	100	.....	.0010	0.	0.	
111,450	1,500	.1692	.....	.02	—.06	
.....	100	.....	.0027	0.	0.	
148,600	2,000	.2300	.....	.03	—.06	
.....	100	.....	.0038	0.	0.	
160,000	.....	.....	.....	.03	—.06	
170,000	.....	.....	.....	.04	—.06	
180,000	.....	.....	.....	.04	—.07	
190,000	.....	.....	.....	.04	—.07	
200,000	.....	.....	.....	.04	—.08	
210,000	.....	.....	.....	.05	—.09	
220,000	.....	.....	.....	.05	—.09	
230,000	.....	.....	.....	.07	—.10	
240,000	.....	.....	.....	.09	—.10	
250,000	.....	.....	.....	.12	—.12	
260,000	.....	.....	.....	.18	—.15	
270,000	.....	.....	.....	.32	—.20	
275,000	3,701	.....	.....	.82	—.24	Ultimate strength.

Failed at some knots 70″ from the end. Maximum deflection developed at this point.

No. 532.

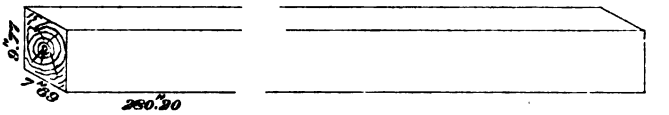


Sectional area, 73.7 square inches.
Gauged length, 200″.
Weight, 391 pounds.
Counterweight at middle, 225 pounds.
Post ¾″ winding before dressing down from size 8″×10″.
Cross-grained stick; season cracks take diagonal direction.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflection.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,370	100	0.	.....	0.	0.	
36,850	500	.0515	.....	—.02	.04	
.....	100	.....	0.	0.	0.	
73,700	1,000	.1190	.....	—.06	.10	
.....	100	.....	.0005	0.	0.	
110,550	1,500	.1865	.....	—.10	.16	
.....	100	.....	.0010	0.	0.	
147,400	2,000	.....	.....	—.19	.25	
160,000	.....	.....	.....	—.22	.29	
170,000	.....	.....	.....	— 26.	.31	
180,000	.....	.....	.....	—.32	.35	
190,000	.....	.....	.....	—.36	.40	
200,000	.....	.....	.....	—.48	.43	
210,000	.....	.....	.....	—.66	.48	
220,000	2,985	.....	.....	—1.08	.54	Ultimate strength.

Failed by horizontal and vertical deflection.

No. 542.

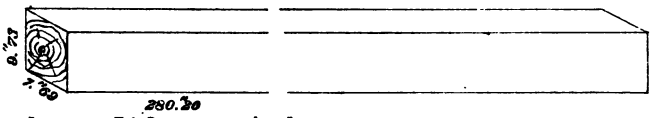


Sectional area, 75.1 square inches.
Gauged length, 200″.
Weight, 501 pounds.
Counterweight at middle, 250 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflection.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,510	100	0.	.....	0.	0.	
37,550	500	.0490	.....	—.01	0.	
.....	100	.....	0.	0.	0.	
75,100	1,000	.1088	.....	—.05	0.	
.....	100	.....	.0010	0.	0.	
112,650	1,500	.1710	.....	—.09	0.	
.....	100	.....	.0030	0.	0.	
150,200	2,000	.2332	.....	—.12	.02	
.....	100	.....	.0053	0.	0.	
160,000	.....	.....	.....	—.15	.03	
170,000	.....	.....	.....	—.17	.04	
180,000	.....	.....	.....	—.20	.05	
190,000	.....	.....	.....	—.24	.06	
200,000	.....	.....	.....	—.30	.08	
210,000	.....	.....	.....	—.38	.10	
220,000	.....	.....	.....	—.61	.12	
225,000	2,996	.....	.....	.....	.....	Ultimate strength.

Failed rapidly by horizontal deflection when the maximum load was reached.

No. 543.

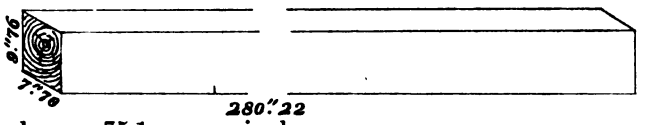


Sectional area, 74.8 square inches.
Gauged length, 200″.
Weight, 501 pounds.
Counterweight at middle, 250 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,480	100	0.	.....	0.	0.	
37,400	500	.0448	.....	.01	.02	
.....	100	.....	—.0005	0.	.01	
74,800	1,000	.1040	.....	.06	.04	
.....	100	.....	0.	0.	.01	
112,200	1,500	.1665	.....	.10	.04	
.....	100	.....	.0020	0.	.01	
149,600	2,000	.2290	.....	.20	.04	
.....	100	.....	.0050	.01	.01	
160,000	.....	.....	.....	.22	.05	
170,000	.....	.....	.....	.26	.05	
180,000	.....	.....	.....	.31	.06	
190,000	.....	.....	.....	.40	.06	
200,000	.....	.....	.....	.50	.07	
210,000	.....	.....	.....	.74	.09	
220,000	.....	.....	.....	1.60	.13	
220,500	2,948	.....	.....	2.10	.13	Ultimate strength.

Failed by horizontal deflection.

No. 544.

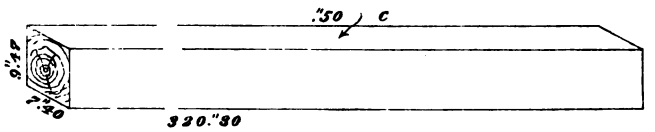


Sectional area, 75.1 square inches.
Gauged length, 200″.
Weight, 560 pounds.
Counterweight at middle, 280 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,510	100	0.	.....	0.	0.	
37,550	500	.0412	.....	0.	—.05	
.....	100	.....	0.	0.	0.	
75,100	1,000	.0900	.....	—.02	—.08	
.....	100	.....	.0004	0.	0.	
112,650	1,500	.1400	.....	—.05	—.11	
.....	100	.....	.0018	0.	0.	
150,200	2,000	.1904	.....	—.06	—.16	
.....	100	.....	.0030	0.	0.	
160,000	.....	.....	.....	—.07	—.16	
170,000	.....	.....	.....	—.07	—.18	
180,000	.....	.....	.....	—.07	—.19	
190,000	.....	.....	.....	—.07	—.20	
200,000	.....	.....	.....	—.07	—.20	
210,000	.....	.....	.....	—.07	—.21	
220,000	.....	.....	.....	—.07	—.22	
230,000	.....	.....	.....	—.07	—.23	
240,000	.....	.....	.....	—.07	—.24	
250,000	.....	.....	.....	—.07	—.25	
260,000	.....	.....	.....	—.07	—.26	
270,000	.....	.....	.....	—.02	—.27	
280,000	.....	.....	.....	+.02	—.29	
290,000	.....	.....	.....	—.16	—.30	
298,000	3,968	.....	.....	.....	.....	Ultimate strength.

Failed by deflecting sideways.

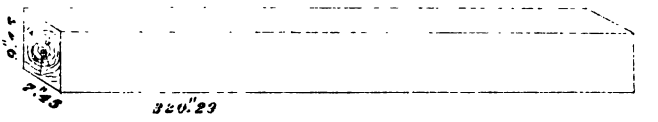
No. 527.



Sectional area, 70 square inches.
Weight, 531 pounds.
Gauged length, 300″.
Counterweight at middle, 300 pounds.
Initial deflection before stick was dressed down from 8″ × 10″: Vertical, — ″.50.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,000	100	0.	.....	0.	0.	
35,000	500	.0625	.....	—.02	—.02	
.....	100	.....	0.	0.	0.	
70,000	1,000	.1428	.....	—.07	—.10	
.....	100	.....	.0068	0.	0.	
105,000	1,500	.2218	.....	—.10	—.16	
.....	100	.....	.0012	0.	0.	
140,000	2,000	.....	.....	—.11	—.23	
210,000	3,000	.....	.....	—.99	—.50	Ultimate strength.

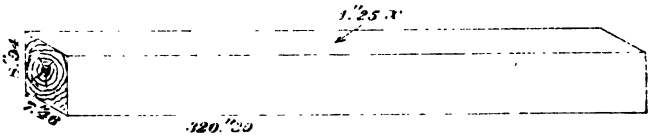
No. 528.



Sectional area, 70.4 square inches.
Weight, 627 pounds.
Counterweight at middle, 300 pounds.
Gauged length, 300″.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
7,140	101	0.		0.	0.	
35,700	507	.0593		−.05	−.03	
	101		0.	0.	0.	
71,400	1,014	.1360		−.10	−.09	
	101		.0015	0.	0.	
107,100	1,521	.2170		−.18	−.14	
	101		.0030	0.	0.	
142,800	2,028			−.30	−.18	
178,500	2,535			−.60	−.25	
205,000	2,912			−2.55	−.40	Ultimate strength.

No. 529.

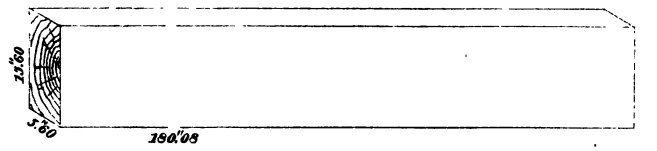


Sectional area, 66.7 square inches.
Weight, 535 pounds.
Counterweight at middle, 300 pounds.
Gauged length, 300″.
Initial deflection before stick was dressed down from size 8″ × 10″: Vertical, + 1″.25.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
6,670	100	0.		0.	0.	
33,350	500	.0680		.01	0.	
	100		0.	0.	0.	
66,700	1,000	.1588		.03	−.09	
	100		0.	0.	0.	
100,050	1,500	.2519		.07	−.20	
	100		.0020	0.	0.	
133,400	2,000			.08	−.38	
140,000				.08	−.45	
150,000				.10	−.53	
160,000				.11	−.70	
166,750	2,500			.15	−.80	
180,000				.38	−1.15	
184,500	2,766			Ab't 2.20	Ab't −1.50	Ultimate strength.

Failed by deflecting sideways and downward.

No. 711.

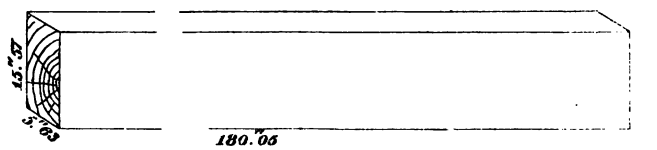


Sectional area, 87.4 square inches.
Gauged length, 150″.
Weight, 375 pounds.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0.	0	0.	.....	0.	0.	0.	
43,700	500	.0491	.....	.03	.01	— .06	
.....	0	.....	.0004	.....	.....	.....	
80,000	.....	.....	.....	.03	.02	.....	
100,000	.....	.....	.....	.03	.06	— .10	
140,000	.....	.....	.....	.03	.09	.....	
180,000	.....	.....	.....	.03	.10	.....	
200,000	.....	.....	.....	.03	.12	— .12	
220,000	.....	.....	.....	.01	.13	.....	
230,000	.....	.....	.....	.01	.14	.....	
240,000	.....	.....	.....	0.	.14	.....	
250,000	.....	.....	.....	0.	.14	.....	
260,000	.....	.....	.....	0.	.15	.....	
270,000	.....	.....	.....	0.	.15	.....	
280,000	.....	.....	.....	— .01	.15	.....	
290,000	.....	.....	.....	— .01	.16	.....	
300,000	.....	.....	.....	— .02	.16	.....	
310,000	.....	.....	.....	— .05	.17	.....	
320,000	.....	.....	.....	— .07	.19	— .15	
330,000	.....	.....	.....	— .11	.20	.....	
340,000	.....	.....	.....	— .20	.20	.....	
349,000	3,993	.....	.....	— .52	.20	.....	Ultimate strength.

Failed by horizontal deflection, minus direction.

No. 712.

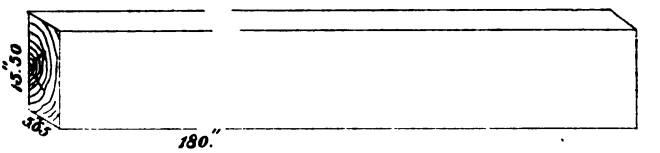


Sectional area, 87.7 square inches.
Gauged length, 150″.
Weight, 397 pounds.
Average rate of growth, 21 rings per inch.
Stick injured by wind-shakes.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	.....	
43,850	500	.0370	.....	0.	.06	.....	
.....	0	.....	0.	.....	.....	.....	
80,000	.....	.....	.....	0.	.08	.....	
100,000	.....	.....	.....	−.01	.10	−.05	
140,000	.....	.....	.....	−.01	.10	.....	
180,000	.....	.....	.....	−.02	.11	.....	
200,000	.....	.....	.....	−.04	.11	−.05	
220,000	.....	.....	.....	−.05	.12	.....	
240,000	.....	.....	.....	−.05	.12	.....	
260,000	.....	.....	.....	−.06	.12	.....	
280,000	.....	.....	.....	−.10	.13	.....	
300,000	.....	.....	.....	−.11	.14	−.07	
310,000	.....	.....	.....	−.17	.14	.....	
320,000	.....	.....	.....	−.24	.15	.....	
330,000	.....	.....	.....	−.33	.15	.....	
339,000	3,865	.....	.....	.....	.....	.....	Ultimate strength.

Failed by horizontal deflection, minus direction.

No. 713.

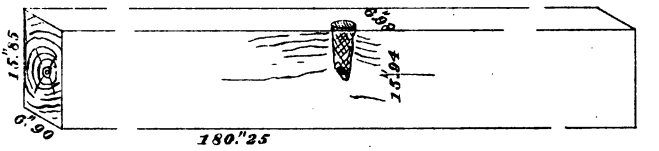


Sectional area, 87.6 square inches.
Gauged length, 150″.
Weight, 382 pounds.
Average rate of growth, 15 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
43,800	500	.0524	.....	−.13	.01	.....	
.....	0	.....	.0006	.....	.....	.....	
80,000	.....	.....	.....	−.15	−.01	.....	
100,000	.....	.....	.....	−.17	−.02	0.	
140,000	.....	.....	.....	−.21	−.02	.....	
180,000	.....	.....	.....	−.28	−.02	.....	
200,000	.....	.....	.....	−.31	−.02	.05	
220,000	.....	.....	.....	−.37	−.02	.....	
240,000	.....	.....	.....	−.43	−.02	.....	
250,000	.....	.....	.....	−.50	−.02	.....	
260,000	.....	.....	.....	−.61	−.04	.....	
270,000	.....	.....	.....	−.98	−.08	.....	
272,500	3,111	.....	.....	−1.17	.....	.....	Ultimate strength.

Failed by horizontal deflection, minus direction.
Fibers crushed at a knot at middle of post.

No. 484.



Sectional area, end, 109.4 square inches.
Sectional area, middle, 111.3 square inches.
Gauged length, 160″.
Weight, 432 pounds.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000		0.		0.	0.	
50,000		.0380		0.	0.	
10,000			.0005	0.	0.	
100,000		.1080		0.	−.02	
10,000			.0015	0.	0.	
150,000		.1685		+.02	−.05	
10,000			.0018	0.	0.	
180,000		.2060		.02	−.05	
200,000		.2332		.02	−.05	Slight snapping sounds.
10,000			.0040	0.	0.	
220,000		.2605		.02	−.07	
240,000		.2910		0.	−.10	
260,000		.3270		−.08	−.15	
270,000	2,468					Ultimate strength.

Sustained maximum load about one minute.

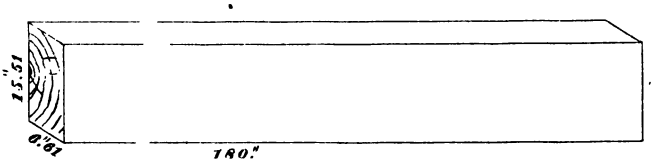
Failed by horizontal deflection. Concave side having large knot near the middle of the post, the heart being 2″ from concave side at one end; opposite end does not have heart in it.

The location of the heart was probably 2″ beyond edge of stick. Post was sawed obliquely with axis of tree running out 4″ in 15 feet; 150 rings of yearly growth in 10″.

Rapid growth during the first years; 6 rings in 1″ at center.

Time of test, one hour.

No. 708.

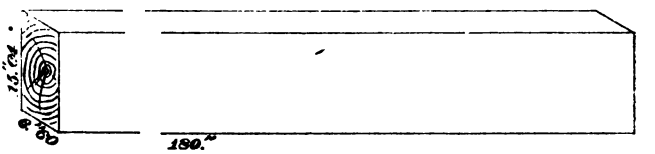


Sectional area, 102.5 square inches.
Gauged length, 150″.
Weight, 464 pounds.
Average rate of growth, 17 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
51,250	500	.0440		— .02	0.		
	0		.0005				
80,000				— .02	0.		
100,000				— .02	0.		
140,000				— .06	.01		
180,000				— .08	.01		
200,000				— .10	.02	— .04	
240,000				— .13	.02		
260,000				— .16	.02		
280,000				— .20	.02		
300,000				— .26	.02		
320,000				— .38	.02		
340,000	3,317			— .60	.08		Ultimate strength.

Failed at some knots at middle of post.

No. 709.



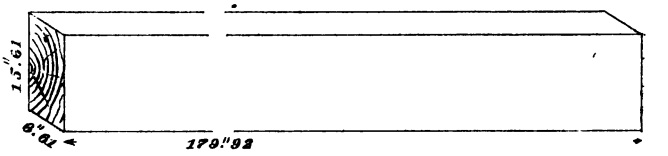
Sectional area, 103.2 square inches.
Gauged length, 150″.
Weight, 557 pounds.
Average rate of growth, 18 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
51,600	500	.0570		— .05	— .09	— .05	
	0		.0008				
80,000				.05	— .09		
100,000				.05	— .09		
140,000				.04	— .09		
180,000				.03	— .09		
200,000				.02	— .09		
240,000				0.	— .09		
280,000				— .01	— .09		
300,000				— .02	— .09	— .10	
320,000				— .05	— .09		
330,000				— .05	— .00		
340,000				— .06	— .09		
350,000				— .07	— .09		
360,000				— .07	— .09		
370,000				— .08	— .09		
380,000				— .09	— .09		
390,000				— .11	— .10		
400,000				— .13	— .10	— .13	
410,000				— .15	— .10		
420,000				— .18	— .10		
430,000				— .21	— .10		
440,000				— .27	— .10		
450,000				— .40	— .10		
455,000	4,409			— .62	— .10		Ultimate strength.

Failed by horizontal deflection, minus direction.

Horizontal deflection increased to — 3″.30; fibers of stick crushed at 1″ to 6½″ from end. Grain straight.

No. 710.



Sectional area, 103.2 square inches.
Gauged length, 150″.
Weight, 491 pounds.
Average rate of growth, 18 rings per inch.

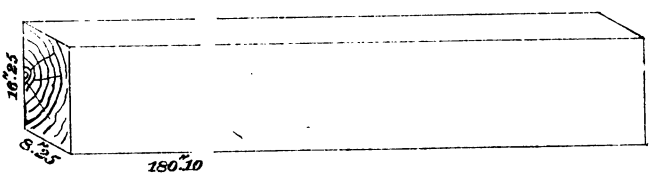
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
51,600	500	.312		— .06	.02	.....	
.....	0	.....	0.	.....	.....	.....	
80,000	.....	.....	.....	— .06	.02	.....	
100,000	.....	.....	.....	— .06	.02	.....	
140,000	.....	.....	.....	— .06	.03	.....	
180,000	.....	.....	.....	— .06	.05	.....	
200,000	.....	.....	.....	— .06	.06	0.	
240,000	.....	.....	.....	— .06	.07	.....	
280,000	.....	.....	.....	— .07	.08	.....	
300,000	.....	.....	.....	— .08	.08	— .02	
340,000	.....	.....	.....	— .09	.09	.....	
360,000	.....	.....	.....	— .10	.09	.....	
380,000	.....	.....	.....	— .11	.09	.....	
400,000	.....	.....	.....	— .16	.10	— .05	
420,000	.....	.....	.....	— .26	.10	.....	
430,000	.....	.....	.....	— .37	.11	.....	
432,000	4,186	.....	.....	— .50*	.....	.....	Ultimate strength.

*About.

Failed by horizontal deflection, minus direction.

Horizontal deflection increased to 3″.20, slightly crushing fibers 29″ from south end, where stick appeared weakened by shakes and seam cracks.

No. 641.

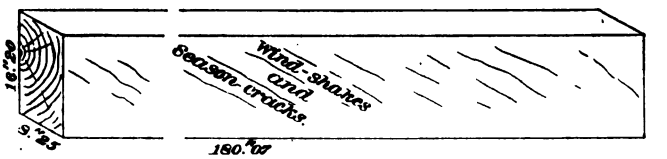


Sectional area, 134 square inches.
Weight, 561 pounds.
Gauged length, 150″.
Average rate of growth, 5 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
13,400	100	0.	.....	0.	0.	
67,000	500	.0380	.....	0.	0.	
107,200	800	.0663	.....	0.	.01	
134,000	1,000	.0851	.....	0.	.01	
.....	100	.....	0.	0.	0.	
150,000	.....	.....	.....	0.	.03	
160,000	.....	.....	.....	0.	.04	
170,000	.....	.....	.....	0.	.05	
180,000	.....	.....	.....	0.	.05	
200,000	.....	.....	.....	0.	.05	
220,000	.....	.....	.....	0.	.05	
240,000	.....	.....	.....	0.	.05	
260,000	.....	.....	.....	0.	.05	
280,000	.....	.....	.....	0.	.06	
300,000	.....	.....	.....	0.	.08	
320,000	.....	.....	.....	0.	.08	
340,000	.....	.....	.....	.01	.09	
360,000	.....	.....	.....	.01	.09	
380,000	.....	.....	.....	.02	.09	
400,000	.....	.....	.....	.04	.09	
410,000	.....	.....	.....	.06	.09	
420,000	.....	.....	.....	.10	.07	
425,000	.....	.....	.....	.13	.05	
428,000	3,194	.....	.....	.18	.02	Ultimate strength.

Failed by crushing fibers at middle and 40″ from end in the vicinity of knots.

No. 671.



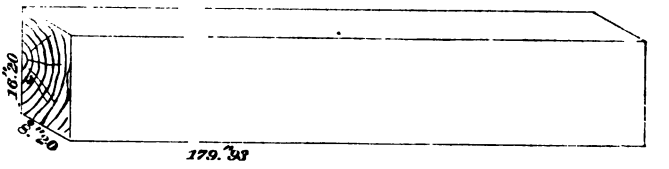
Sectional area, 133 square inches.
Gauged length, 150″.
Weight, 585 pounds.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
66,800	500	.0612	.....	−.01	0.	0.	
0	.....	.....	.0006	.....	.....	.....	
80,000	.....	.....	.....	−.01	0.	0.	
100,000	.....	.....	.....	−.02	.01	.01	
140,000	.....	.....	.....	−.02	.01	.....	
180,000	.....	.....	.....	−.03	.02	.....	
200,000	.....	.....	.....	−.04	.03	.01	
220,000	.....	.....	.....	−.05	.03	.....	
240,000	.....	.....	.....	−.05	.04	.....	
260,000	.....	.....	.....	−.06	.05	.....	
280,000	.....	.....	.....	−.07	.05	.....	
300,000	.....	.....	.....	−.07	.05	.01	
320,000	.....	.....	.....	−.08	.06	.....	
340,000	.....	.....	.....	−.09	.06	.....	
360,000	.....	.....	.....	−.11	.06	.....	
380,000	.....	.....	.....	−.15	.07	.....	
400,000	.....	.....	.....	−.20	.08	.01	
420,000	.....	.....	.....	−.40	.08	.....	
425,000	3,181	.....	.....	−.88	.08	.....	Ultimate strength.

Failed by horizontal deflection, minus direction.

When horizontal deflection had reached about —1″.35, a chalk-line was laid off on stick and ordinates measured every 12″, showing the curve of flexure as per the following sketch:

No. 672.

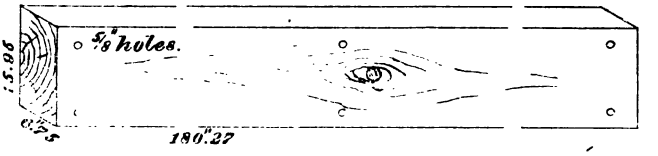


Sectional area, 132.8 square inches.
Gauged length, 150″.
Weight, 578 pounds.
Average rate of growth, 13 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.		0.	0.	0.	
66,400	500	.0535		— .01	0.		
0	0		0.				
80,000				— .01	0.		
100,000				— .01	0.		
140,000				— .01	0.		
180,000				— .01	0.		
200,000				— .01	0.	— .02	
240,000				— .01	0.		
260,000				— .01	0.		
280,000				— .02	0.		
300,000				— .03	0.	— .04	
320,000				— .03	0.		
340,000				— .03	0.		
360,000				— .03	0.		
380,000				— .03	0.		
400,000				— .04	— .01	— .07	
410,000				— .05	— .01		
420,000				— .05	— .02		
430,000				— .05	— .02		
440,000				— .05	— .03		
450,000				— .05	— .03		
460,000				— .05	— .03		
470,000				— .05	— .05		
480,000				— .05	— .06		
490,000				— .04	— .07		
500,000				— .03	— .09	— .17	
510,000				— .01	— .11		
520,000				+ .01	— .15		
526,000	3,961			.25	— .20		Ultimate strength.

Failed by horizontal deflection, plus direction.

No. 485.

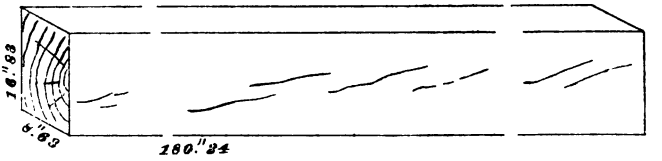


Sectional area, 107.7 square inches.
Weight, 434 pounds.
This stick taken from built post No. 691, which was tested March 11, 1881. It failed at the knot near middle in the original test, under 3,070 pounds per square inch compression.
The test was discontinued soon as the maximum load was passed, and the stick placed in the storehouse to season. Allowed to season thirteen months and then tested.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000				0.	0.	
50,000				.05	.02	
100,000				.40	0.	
120,600				.62	0.	
120,000				.70	0.	Sustained load 5 minutes.
130,000				.80	0.	Sustained load 5 minutes.
130,000				.90	0.	
140,000				.92	0.	Sustained load 3 minutes.
140.000				1.00	0.	
150,000				1.10	0.	Sustained load 5 minutes.
150,000				1.23	0.	
160,000				1.35	0.	Sustained load 5 minutes.
160,000				1.50	0.	
165,000				1.56	0.	
170,000				1.70	0.	
175,000	1,625			1.90		Ultimate strength.

Sustained maximum load momentarily.
Failed by horizontal deflection; concave on the side having the knot.
Fibers crushed at middle knot and opened longitudinal crack.
Time of test three-quarters of an hour.

No. 486.



Sectional area, 145.2 square inches.
Gauged length, 160″.
Weight, 705 pounds.
Second test of post No. 714. Ultimate strength found by the first test, 456,000 pounds=3,180 pounds per square inch.
Rested in storehouse thirteen months, and again tested.
Grain of specimen oblique to axis.
Post free from knots.

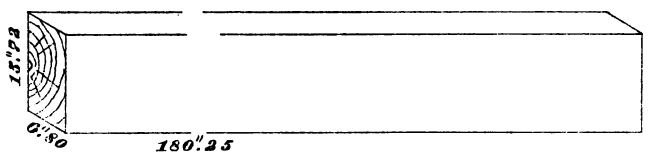
Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000		0.		0.	0.	
50,000		.0265		0.	+.02	
10,000			0.	0.	0.	
100,000		.0640		0.	.10	
10,000			.0010	0.	0.	
200,000		.1520		0.	.25	Snapping sounds heard.
10,000			.0080	0.	0.	
220,000				0.	.30	
240,000				0.	.30	
260,000				0.	.35	
280,000				0.	.40	
300,000				0.	.46	
300,000				0.	.50	Sustained load 5 minutes.
320,000				0.	.55	
340,000				0.	.65	
340,000				0.	.70	Sustained load 3 minutes.
360,000				0.	.75	
380,000	2,617			0.	.85	Ultimate strength.

Sustained maximum load momentarily, then opened cracks rapidly as the pressure was gradually allowed to fall.

The longitudinal cracks were oblique with axis of post at an angle of about 5°.

The development of the cracks began at 200,000 pounds.

No. 487.



Sectional area, 106.9 square inches.

Gauged length, 160″.

Weight, 450 pounds.

Initial bend, ″.44; 1 sine.

Post free from knots.

This post was tested March 11, 1881, at that time sustaining 317,000 pounds = 2,795 pounds per square inch.

Second test made after rest of thirteen months nine days.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000		0.		0.	0.	
50,000		.0282		0.	0.	
10,000			0.	0.	0.	
100,000		.0690		−.10	0.	
10,000			.0015	0.	0.	
150,000		.1120		−.20	0.	
10,000			.0040	−.04	0.	
200,000		.1600		−.30	.05	
10,000			.0080	−.07	0.	
220,000				−.40	.10	
240,000				−.48	.15	
240,000				−.50	.15	Sustained load 5 minutes.
260,000				−.60	.15	
270,000				−.65	.15	
280,000				−.72	.20	
290,000				−.80	.20	
300,000				−.90	.20	
305,000				−1.05	.20	
305,000				−1.25	.25	Sustained load 5 minutes.
310,000	2,900					Ultimate strength.

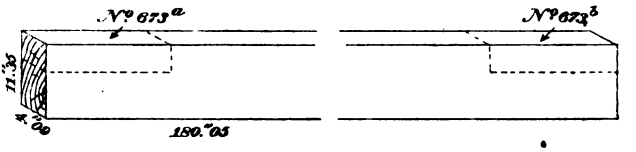
Sustained maximum load about five minutes, yielding laterally in the mean time, following the direction of the initial bend; convex on heart-side of post.

Time of test three-quarters of an hour.

COMPRESSION TESTS OF YELLOW PINE—(Continued).

SINGLE STICKS AND BUILT POSTS.

No. 673.



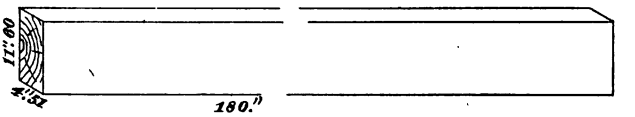
Sectional area, 46.4 square inches.
Gauged length, 150″.
Weight, 260 pounds.
Average rate of growth, 11 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical. E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	0.	0.	0.	North end of stick very resinous.
23,200	500	.0370	.....	−.01	0.	.....	
0	0	.....	.0028	.....	.....	.....	
30,000	.....	.....	.....	−.01	0.	.....	
40,000	.....	.....	.....	−.01	.01	.....	
50,000	.....	.....	.....	−.01	.02	−.04	
60,000	.....	.....	.....	−.01	.03	.....	
70,000	.....	.....	.....	−.01	.06	.....	
80,000	.....	.....	.....	−.01	.07	.....	
90,000	.....	.....	.....	−.03	.09	.....	
100,000	.....	.....	.....	−.05	.10	−.08	
110,000	.....	.....	.....	−.09	.11	.....	
120,000	.....	.....	.....	−.13	.12	.....	
130,000	.....	.....	.....	−.22	.13	.....	
140,000	.....	.....	.....	−.50	.13	.....	
142,200	3,065	.....	.....	−.95	.....	.....	Ultimate strength.
Failed by horizontal deflection, minus direction.							
120,000	2,586	.....	.....	−2.50	.....	.....	Sudden deflection increasing −5″.

Specimen No. 673*a*, 20″ long, cut from north end of stick.
Specimen No. 673*b*, 20″ long, cut from south end of stick.

Specimen.	Weight.	Size.	Sectional area.	Ultimate strength.		Remarks.
				Actual.	Pounds per square inch.	
	Pounds.	*Inches.*	*Sq. inches.*	*Pounds.*		
673*a*	13	4.01 × 4.01	16.08	94,000	5,846	Fibers crushed.
673*b*	7¼	3.95 × 3.97	15.68	99,600	6,352	Fibers crushed; small rent in specimen at corner not affecting over 5 per cent. of sectional area of stick.

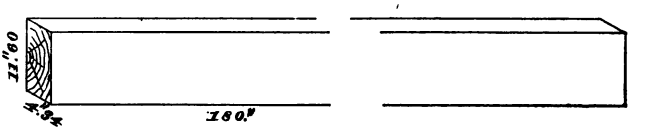
No. 674.



Sectional area, 52.3 square inches.
Gauged length, 150″.
Weight, 233 pounds.
Average rate of growth, 17 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	0.	0.	0.	0.	
26,150	500	.0492	.....	— .07	— .03	— .04	
.....	0	.....	.0003	.....	.....	.....	
30,000	.....	.....	.....	— .09	— .03	.....	
40,000	.....	.....	.....	— .10	— .03	.....	
50,000	.....	.....	.....	— .11	— .03	.....	
60,000	.....	.....	.....	— .14	— .04	.....	
70,000	.....	.....	.....	— .17	— .05	.....	
80,000	.....	.....	.....	— .20	— .06	.....	
90,000	.....	.....	.....	— .25	— .07	.....	
100,000	.....	.....	.....	— .32	— .08	— .08	
110,000	.....	.....	.....	— .41	— .09	.....	
120,000	.....	.....	.....	— .58	— .09	.....	
130,000	.....	.....	.....	—1.00	— .10	.....	
131,500	2,515	.....	.....	—1.30	— .12	.....	Ultimate strength.
Failed by horizontal deflection, minus direction.							
110,000	.....	.....	.....	—3.30	.....	.....	Sudden spring, increasing horizontal deflection to — 5″.

No. 675.

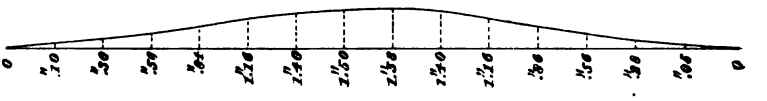


Sectional area, 50.3 square inches.
Gauged length, 150″.
Weight, 194 pounds.
Average rate of growth, 22 rings per inch.

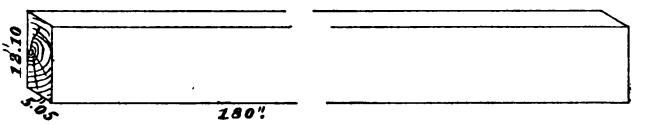
Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
25,150	500	.0490	.....	.01	0.	.....	
.....	0	.....	.0006	.....	.....	.....	
30,000	.....	.....	.....	.02	0,	.....	
40,000	.....	.....	.....	.02	0.	.....	
50,000	.....	.....	.....	.03	0.	.01	
60,000	.....	.....	.....	.04	— .01	.....	
70,000	.....	.....	.....	.05	— .02	.....	
80,000	.....	.....	.....	.07	— .02	.....	
90,000	.....	.....	.....	.10	— .03	.....	
100,000	.....	.....	.....	.15	— .03	.05	
110,000	.....	.....	.....	.24	— .04	.....	
120,000	.....	.....	.....	.65	— .05	.....	
121,200	2,410	.....	.....	.90	— .05	.....	Ultimate strength.

Failed by horizontal deflection, minus direction.

Sketch showing of flexure, ordinates measured every 12″.



No. 490.

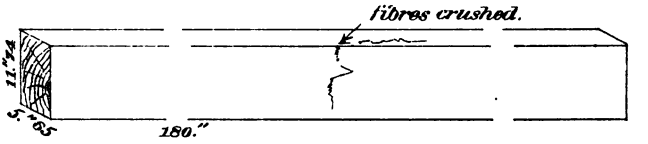


Sectional area, 61.1 square inches.
Weight, 269 pounds.
Gauged length, 160″.
Post free from knots.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000	.....	0.	0.	0.	0.	
20,000	.....	.0140	.....	0.	0.	
40,000	.....	.0416	.....	— .01	0.	
50,000	.....	.0570	.....	— .02	0.	
10,000	.....	.....	.0010	0.	0.	
60,000	.....	.0708	.....	— .02	0.	
80,000	.....	.0995	.....	— .02	0.	
100,000	.....	.1318	.....	— .03	0.	
10,000	.....	.....	.0035	0.	0.	
120,000	.....	.1615	.....	— .04	0.	
140,000	.....	.1900	.....	— .04	0.	Snapping sound heard; sliver starting off at edge.
150,000	.....	.2070	.....	— .05	0.	
10,000	.....	.....	.0060	.....	.....	Rested 2 minutes.
10,000	.....	.....	.0040	.....	.....	Rested 5 minutes.
160,000	.....	.2220	.....	— .05	0.	
180,000	.....	.2524	.....	— .05	0.	
200,000	.....	.2873	.....	— .05	0.	
10,000	.....	.....	.0098	0.	0.	
230,000	3,764	.....	.....	+ .01	0.	Ultimate strength.
230,000	.....	.....	.....	+1.30	0.	After sustaining load 4 minutes.
230,000	.....	.....	.....	+1.80	0.	Maximum deflection.
10,000	.....	.....	.....	+ .40	0.	

Time of test, one hour.
Failed by horizontal deflection.
Deflections changed in direction horizontally when the maximum load was reached.
Failing finally by bending concave on the heart-side of the post.

No. 670.

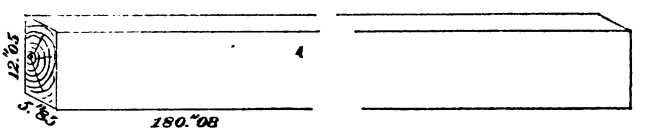


Sectional area, 66.3 square inches.
Gauged length, 150".
Weight, 309 pounds.
Average rate of growth, 12 rings per inch.

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Deflections.			Remarks.
				Horizontal.	Vertical, W.	Vertical, E.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	
0	0	0.	.....	0.	0.	0.	
33,150	500	.0455	.....	0.	— .04	.....	
0	0	.....	.0005	.....	.....	.....	
50,000	.....	.....	.....	— .01	— .06	.....	
70,000	.....	.....	.....	— .02	— .09	.....	
90,000	.....	.....	.....	— .02	— .11	.....	
100,000	.....	.....	.....	— .02	— .11	.10	
120,000	.....	.....	.....	0.	— .15	.....	
140,000	.....	.....	.....	.02	— .18	.....	
150,000	.....	.....	.....	.04	— .20	.15	
160,000	.....	.....	.....	.07	— .20	.....	
170,000	.....	.....	.....	.10	— .21	.....	
180,000	.....	.....	.....	.13	— .23	.....	
190,000	.....	.....	.....	.18	— .25	.....	
200,000	.....	.....	.....	.31	— .28	.23	
205,900	3,106	.....	.....	.70	— .29	.....	Ultimate strength.

Failed by horizontal deflection, plus direction.
Fibers crushed near middle of stick, line of failure taking an oblique course.

No. 489.



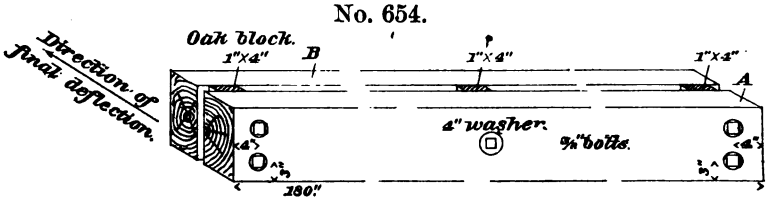
Sectional area, 70.5 square inches.
Weight, 287 pounds.
Gauged length, 160".
Post free from knots.

Loads applied.	Pounds square per inch.	Compression.	Compression set.	Deflections. Horizontal.	Deflections. Vertical, W.	Remarks.
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000		0.	0.	0.	0.	
20,000		.0114		0.	0.	
40,000		.0368		—.01	0.	
50,000		.0405		—.02	0.	
10,000			0.	0.	0.	
60,000		.0630		—.02	0.	
80,000		.0895		—.04	0.	
100,000		.1162		—.04	0.	
10,000			.0004	0.	0.	
120,000		.1435		—.08	0.	
140,000		.1710		—.10	0.	
150,000		.1850		—.10	0.	
10,000			.0025	0.	0.	
160,000		.1980		—.12	0.	[minutes.
160,000		.2008		—.12	0.	Sustained load 5
160,000		.2020		—.12	0.	Sustained load 10
170,000		.2160		—.15	0.	minutes.
180,000		.2295		—.18	0.	
180,000		.2310		—.20	0.	
190,000		.2450		—.20	0.	
200,000		.2585		—.21	0.	
10,000			.0082	—.01	0.	
10,000			.0060	—.01	0.	After 5 minutes
210,000				—.27	0.	rest.
220,000				—.31	0.	
230,000				—.38	0.	
240,000				—.50	0.	
250,000	3,546			—.73	0.	Ultimate strength.
250,000				—1.26		Sustained load 5 minutes.

Failed by horizontal deflection; convex on heart-side of post. After sustaining load five minutes, horizontal deflection increased rapidly, opening longitudinal cracks along middle of post near the heart of the wood.

Time of test one and a half hours.

No. 654.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	326	11	180	5.63	11.71	65.9	150
B	290	6	180	5.62	11.71	65.9	150
	616					131.8	

Stick.	Loads applied. Actual.	Loads applied. Pounds per sq. inch.	Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Pounds		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,950	500	.0418	.0002	.03	0.
B	32,950	500	.0540	0.	0.	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	0.	
40,000	0.	0.	0.	
80,000	0.	0.	0.	
100,000	0.	0.	0.	
140,000	0.	.01	—.01	
180,000	0.	.02	—.02	
200,000	0.	.02	—.02	
220,000	0.	.03	—.03	
240,000	0.	.04	—.03	
260,000	0.	.05	—.03	
280,000	.01	.07	—.04	
300,000	.01	.08	—.04	
320,000	.03	.09	—.04	
340,000	.04	.10	—.04	
360,000	.05	.11	—.04	
380,000	.07	.12	—.04	
400,000	.10	.14	—.04	
410,000	.11	.15	—.04	
420,000	.12	.16	—.04	
430,000	.14	.16	—.04	
440,000	.20	.18	—.04	
450,000	.23	.20	—.04	
460,000	.29	.22	—.04	
470,000	.39	.22	—.04	Ultimate strength = 3,566 pounds per square inch.

Failed by horizontal deflection, plus direction.

No. 655.

Same style of post as No. 654.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	292	34	179.93	5.64	11.72	66.1	150
B	329	24	179.93	5.63	11.72	66.1	150
	621	.....	.....	.....	.....	132.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per sq. inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	33,050	500	.0292	0.	.03	0.
B	33,050	500	.0315	.0007	0.	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	0.	Sticks straight-grained, free from knots.
40,000	0.	0.	0.	
80,000	0.	.01	—.01	
100,000	0.	.02	—.01	
140,000	0.	.02	—.01	
180,000	0.	.01	—.01	
200,000	0.	.01	—.01	
240,000	0.	.01	—.01	
280,000	0.	.01	—.01	
300,000	0.	.01	—.01	
320,000	0.	.01	—.01	
340,000	0.	0.	0.	
350,000	0.	0.	0.	
360,000	0.	0.	0.	
370,000	0.	0.	0.	
380,000	0.	0.	0.	
390,000	0.	0.	0.	
400,000	0.	0.	0.	
410,000	0.	0.	0.	
420,000	0.	—.01	.01	
430,000	—.01	—.01	.01	
440,000	—.01	—.01	.01	
450,000	—.01	—.01	.01	
460,000	—.01	—.01	.01	
470,000	—.01	—.01	.01	
480,000	—.01	—.01	.01	
490,000	—.01	—.01	.01	
500,000	—.01	—.01	.01	
510,000	0.	—.02	.02	
520,000	0.	—.03	.03	
530,000	.01	—.04	.04	
540,000	.02	—.05	.05	
550,000	.05	—.06	.....	
560,000	.10	—.08	.....	
570,000	.17	—.09	.....	
580,000	.....	.....	.....	Ultimate strength = 4,387 pounds per square inch.
Failed by horizontal deflection in plus direction. Loads continued after passing the ultimate strength, increasing the horizontal deflection.				
527,000	1.30	Maximum load now sustained.		
10,000	.....	Rested 36 hours.		
7,500	.....	Load on post at end of 36 hours.		
509,000	1.40	Maximum load sustained after 36 hours' rest.		

No. 656.

Same style of post as No. 654.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	282	13	180	5.61	11.71	65.7	150
B	287	11	180	5.61	11.71	65.7	150
	569	.....	.....	.....	.....	131.4	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,850	500	.0368	.0002	−.02	0.
B	32,850	509	.0466	.0008	−.06	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	0.	
40,000	0.	+.01	−.01	
80,000	0.	+.01	−.01	
100,000	0.	.02	0.	
140,000	−.01	.02	0.	
180,000	−.04	.01	0.	
200,000	−.04	.01	0.	
220,000	−.05	.01	0.	
240,000	−.06	0.	.01	
260,000	−.06	0.	.01	
280,000	−.07	0.	.01	
300,000	−.07	−.01	.02	
320,000	−.08	−.01	.02	
340,000	−.09	−.01	.02	
360,000	−.10	−.01	.02	
380,000	−.11	−.01	.02	
400,000	−.12	−.02	.....	
420,000	−.16	−.02	.....	
440,000	−.21	−.04	+.04	
450,000	−.27	−.04	+.04	
460,000	−.33	−.04	+.04	
470,000	−.52	−.04	+.04	
480,000	−.65	−.04	+.04	Ultimate strength = 3,653 pounds per square inch.

Failed by horizontal deflection, minus direction.

No. 651.

YELLOW PINE, SWELLED POSTS.

1" spaces at ends.
1½" space at middle.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inhes.*	*Inches.*
A	262	11	180	5.58	11.71	65.3	150
B	275	7	180	5.58	11.71	65.3	150
	537	.....	.....	.....	.....	130.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,650	500	.0620	.0014	−.19	−.02
B	32,650	500	.0514	.0008	.13	0.

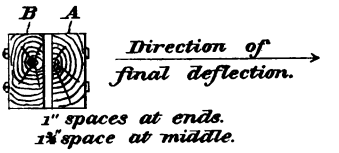
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	.....	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
60,000	0.	0.	.....	
80,000	0.	0.	.....	
100,000	0.	0.	.....	
120,000	0.	0.	.....	
140,000	0.	0.	.....	
160,000	0.	0.	.....	
180,000	0.	0.	.....	
200,000	0.	0.	.....	
220,000	0.	−.01	+.02	
240,000	0.	−.02	+.04	
260,000	0.	−.03	.05	
280,000	0.	−.04	.05	
300,000	0.	−.05	.06	
320,000	0.	−.07	.07	
340,000	0.	−.09	.09	
360,000	.07	−.11	.11	Ultimate strength = 2,756 pounds per square inch.
360,000	.47	−.17	.....	After sustaining load 5 minutes.

Post failed by horizontal deflection in plus direction.

No. 652.

Same style of post as No. 651.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	310	16	180	5.58	11.70	65.3	150
B	370	16	180	5.58	11.71	65.3	150
	680	.....	.....	.....	.....	130.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,650	500	.0395	.0008	—.20	0.
B	32,650	500	.0360	.0002	.18	.03

Transversely the sticks bend an equal amount when bolted together.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	Sticks A and B straight grained and free from knots.
20,000	0.	0.	0.	
40,000	0.	—.01	—.01	
60,000	0.	—.01	—.01	
80,000	0.	—.01	—.01	
100,000	0.	—.01	—.01	
140,000	0.	0.	0.	
180,000	0.	0.	0.	
200,000	0.	0.	0.	
220,000	0.	0.	0.	
240,000	0.	0.	0.	
260,000	0.	—.01	+.01	
280,000	0.	—.01	.01	
300,000	0.	—.01	.01	
320,000	0.	—.01	.01	
340,000	0.	—.01	.01	
360,000	0.	—.02	.02	
380,000	0.	—.02	.02	
400,000	0.	—.02	.02	
410,000	0.	—.03	.03	
420,000	0.	—.04	.04	
430,000	0.	—.04	.04	
440,000	0.	—.04	.04	

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
450,000	0.	— .05	.05	
460,000	0.	— .05	.05	
470,000	0.	— .05	.05	
480,000	0.	— .05	.05	
490,000	0.	— .05	.05	
500,000	0.	— .05	.05	
510,000	0.	— .05	.05	
520,000	0.	— .05	.05	
530,000	0.	— .05	.05	
540,000	0.	— .05	.05	
550,000	0.	— .06	.05	
560,000	— .01	— .06	.05	
570,000	— .02	— .06	.05	
580,000	— .09	— .06	.05	
585,000	— .17	— .06	.05	
588,500	— .36	— .06	.05	Ultimate strength = 4,506 pounds per square inch.

Failed by horizontal deflection in minus direction.

No. 653.

Same style of post as No. 651.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	310	16	180	5.63	11.71	65.9	150
B	311	12	180	5.59	11.68	65.3	150
	621	.....	.....	.....	.....	131.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,950	500	.0559	.0008	— .26	— .01
B	32,650	500	.0550	0.	— .12	.02

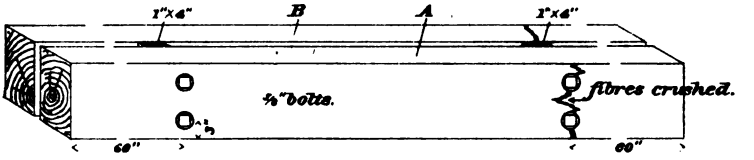
Transversely the sticks bend an equal amount when bolted together.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	.01	0.	
40,000	0.	.01	0.	
80,000	0.	.02	0.	
100,000	.01	.02	0.	
140,000	.01	.02	0.	
160,000	.01	.02	0.	
180,000	.01	.02	0.	
200,000	.02	.02	0.	
220,000	.02	.02	0.	
240,000	.02	.02	0.	
260,000	.03	.01	0.	
280,000	.05	.01	0.	
300,000	.05	.01	0.	
320,000	.06	.01	0.	
340,000	.09	.01	0.	
360,000	.10	.01	0.	
370,000	.11	.01	0.	
390,000	.14	.01	0.	
400,000	.16	.01	0.	
410,000	.20	.01	0.	
420,000	.28	.01	0.	
430,000	.40	.01	0.	
436,600	.60	.01	0.	Ultmate strength = 3,328 pounds per square inch.

Stick B failed 32″ from middle, fibers crushing at a group of knots. Post took horizontal deflection in plus direction.

No. 657.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	340	9	179.96	5.63	11.72	66.0	150
B	319	13	179.96	5.64	11.71	66.0	150
	659	.....	.....	.....	.....	132.0	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	33,000	500	.0375	0.	—.05	—.01
B	33,000	500	.0305	0.	—.02	0.

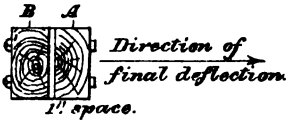
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	.01	0.	
40,000	0.	.02	.....	
80,000	0.	.04	.04	
100,000	0.	.06	.....	
140,000	0.	.10	.....	
180,000	0.	.12	.....	
200,000	0.	.14	.10	
220,000	0.	.15	.....	
240,000	0.	.16	.....	
260,000	0.	.18	.....	
280,000	0.	.20	.....	
300,000	0.	.21	.12	
320,000	0.	.23	.....	
340,000	0.	.25	.....	
360,000	0.	.27	.....	
380,000	0.	.29	.....	
400,000	0.	.31	.....	
420,000	0.	.32	.15	
440,000	0.	.35	.....	
460,000	0.	.37	.....	
480,000	0.	.40	.....	
500,000	0.	.42	.....	
520,000	0.	.47	.....	
540,000	0.	.50	.....	
560,000	—.02	.57	.....	
580,000	—.09	.65	.....	Ultimate strength = 4,394 pounds per square inch.

Failed by crushing fibers at bolt-holes.

No. 658.

Same style of post as No. 657.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	319	12	179.98	5.59	11.71	65.5	150
B	332	9	179.98	5.59	11.72	65.5	150
	651	.....	.....	.....	.....	131.0	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,750	500	.0320	.0005	.08	0.
B	32,750	500	.0436	.0008	—.04	0.

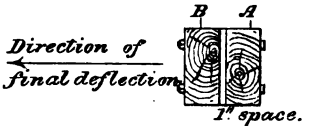
Test of the built post.

Loads applied.	Deflections. Horizontal.	Vertical, W.	Vertical, E.	Remarks.
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	Sticks in poor condition; contain bad shakes and season-cracks. Oblique to axis of sticks.
20,000	0.	0.	.....	
40,000	.02	.07	— .07	
80,000	.02	.12	.....	
100,000	0.	.15	.....	
140,000	0.	.20	.....	
180,000	0.	.25	.....	
200,000	— .01	.28	— .28	
220,000	— .02	.30	.....	
240,000	— .04	.32	.....	
260,000	— .05	.33	.....	
280,000	— .06	.35	.....	
300,000	— .08	.35	— .20	
320,000	— .10	.35	.....	
340,000	— .12	.35	.....	
360,000	— .15	.35	.....	
380,000	— .17	.35	.....	
400,000	— .21	.33	— .07	
410,000	— .27	.25	0.	
420,000	— .30	.15	.....	
425,000	— .41	— .10	+ .55	
430,000	— .48	— .12	.....	
440,000	— .58	— .27	.....	
445,000	— .75	— .41	.....	
448,000	—1.00	— .60	.....	Ultimate strength = 3,420 pounds per square inch.

Stick B failed by opening oblique season-cracks, and shakes taking a minus horizontal deflection.

No. 659.

Same style of post as No. 657.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	320	12	180	5.61	11.73	65.8	150
B	293	8	180	5.61	11.73	65.8	150
	613	.....	.....	.....	.....	131.6	.....

Stick.	Loads applied. Actual.	Loads applied. Pounds per square inch.	Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	32,900	500	.0312	0.	.04	0.
B	32,900	500	.0372	.0002	— .01	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	0.	0.	.....	
40,000	0.	0.	.....	
80,000	0.	0.	.....	
100,000	0.	0.	.....	
140,000	0.	0.	.....	
180,000	0.	0.	.....	
200,000	0.	— .02	.13	
220,000	.01	— .03	.....	
240,000	.02	— .03	.15	
260,000	.03	— .04	.....	
280,000	.03	— .05	.....	
300,000	.04	— .05	.20	
320,000	.05	— .05	.....	
340,000	.06	— .06	.....	
360,000	.07	— .07	.....	
380,000	.08	— .08	.....	
400,000	.10	— .09	.27	
440,000	.12	— .09	.....	
480,000	.15	— .09	.35	
500,000	.17	— .08	.....	
520,000	.20	— .07	.....	
540,000	.24	— .07	.....	
560,000	.30	— .04	.....	
580,000	.45	— .03	.....	
600,000	.70	0.	.47	Ultimate strength = 4,559 pounds per square inch.

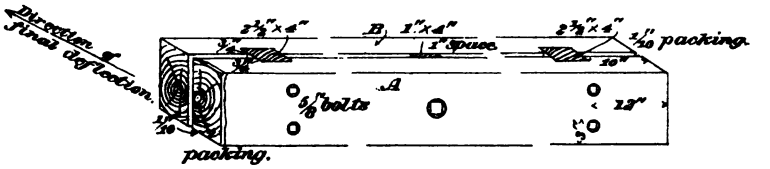
Failed by horizontal deflection, plus direction.

Deflection increased to 1″.40 horizontal without crushing fibers of either stick.

YELLOW PINE, BUILT POSTS.

End packing blocks let into sticks.

No. 660.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	283	25	180.03	5.61	11.22	62.9	150
B	294	18	180.03	5.63	11.24	63.3	150
	577	.....	.....	.....	.....	126.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	31,450	500	.0325	0.	.08	0.
B	31,650	500	.0400	0.	0.	0.

Test of the built post.

Tested with uneven bearings.

Strips of yellow-pine packing $\frac{1}{10}''$ thick placed between ends of sticks and compression platform, one strip behind end of stick A, and one strip behind opposite end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.				
10,000	0.	0.	0.	
20,000	0.	.01	.....	
40,000	0.	.02	.....	Ends not packed came to full bearing.
60,000	0.	.03	.....	
80,000	0.	.03	.....	
100,000	0.	.04	— .02	
140,000	0.	.04	.....	
180,000	.01	.05	.....	
200,000	.01	.05	.....	
240,000	.02	.05	.....	
280,000	.03	.06	.....	
300,000	.03	.06	— .03	
320,000	.03	.06	.....	
360,000	.03	.06	.....	
400,000	.05	.06	.....	
420,000	.06	.07	.....	
440,000	.09	.07	.....	
460,000	.10	.07	.....	
480,000	.15	.07	.....	
500,000	.21	.07	— .05	
510,000	.80	0.	.....	Ultimate strength = 4,041 pounds per square inch.

Failed by horizontal deflection, plus direction.

The deflection was increased to 2″.40 horizontal. At this time the fibers of the sticks had crushed at middle and where the packing pieces were notched in near the ends.

No. 661.

Same style of post as No. 660.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Ganged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	274	12	180	5.66	11.70	66.2	150
B	310	9	180	5.60	11.72	65.6	150
	584	.....	.....	.....	.....	131.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	33,100	500	.0410	0.	— .01	0.
B	32,800	500	.0365	0.	— .03	0.

Test of the built post.

Tested with uneven bearings.

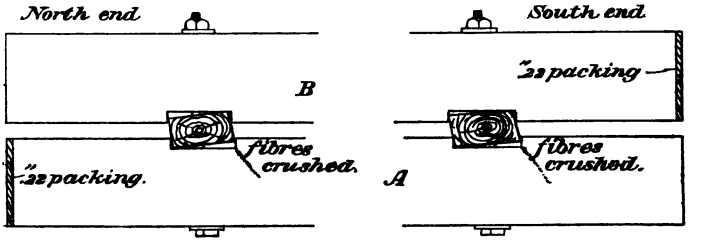
Strip of yellow pine ".22 thick placed behind north ends of stick A; same thickness of packing placed behind south end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	— .01	0.	.....	
30,000	— .03	.04	.....	Deflection rods readjusted.
	0.	0.	0.	
40,000	— .07	.10	.....	
45,000	.....	.....	.....	Ends not packed reach full bearing.
50,000	— .14	.14	.....	
60,000	— .10	.14	— .04	
80,000	— .10	.14	.....	
100,000	— .10	.14	.....	
140,000	— .04	.15	.....	
180,000	— .01	.15	.....	
200,000	0.	.15	— .05	
220,000	0.	.15	.....	
240,000	0.	.15	.....	
260,000	0.	.15	.....	
280,000	+ .01	.14	.....	
300,000	.03	.14	.....	
320,000	.06	.13	.....	
340,000	.09	.13	.....	
360,000	.12	.13	.....	
380,000	.20	.13	.....	
400,000	.40	.15	+ .07	
410,000	.76	.17	.....	Ultimate strength = 3,111 pounds per square inch.

Failed by horizontal deflection, plus direction.

Deflections were increased after the maximum load was passed to develop lines of failure by crushing the fibers of the sticks.

Fibers of stick A crushed 15" from middle and at notched ends, as shown by sketches below:



No. 662.

Same style of post as No. 660.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	292	14	180	5.61	11.75	65.9	150
B	280	8	180	5.61	11.75	65.9	150
	572	.....	.....	.....	.....	131.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch*	*Inch.*
A	32,950	500	.0540	0.	+ .10	0.
B	32,950	500	.0500	.0004	— .09	0.

Test of the built post.

Yellow-pine strips, ".32 thick, placed behind north end of stick A; same amount of packing placed behind south end of stick B.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
10,000	0.	0.	0.	
20,000	— .03	— .01	.....	
30,000	— .08	— .04	.07	Washers of end bolts are drawn into the wood about $\frac{1}{16}$". South end of stick A takes a bearing. North end of stick B takes a bearing.
40,000	— .11	— .08	.....	
50,000	— .06	— .06	.....	
60,000	— .02	— .05	.....	
70,000	— .01	— .05	.....	
80,000	— .01	— .05	.....	
90,000	— .01	— .05	.....	
100,000	— .01	— .05	.08	
120,000	— .04	— .02	.....	
140,000	— .05	— .01	.....	
160,000	— .07	— .01	.....	
180,000	— .08	0.	.....	
200,000	— .10	0.	.05	
220,000	— .11	0.	.....	
240,000	— .12	0.	.....	
260,000	— .13	0.	.....	
280,000	— .15	0.	.....	
300,000	— .19	0.	.05	
320,000	— .21	0.	.....	
340,000	— .29	0.	.....	
360,000	— .37	0.	.....	
380,000	— .52	0.	.....	
388,000	—1.08	— .02	.....	Ultimate strength = 2,944 pounds per square inch.

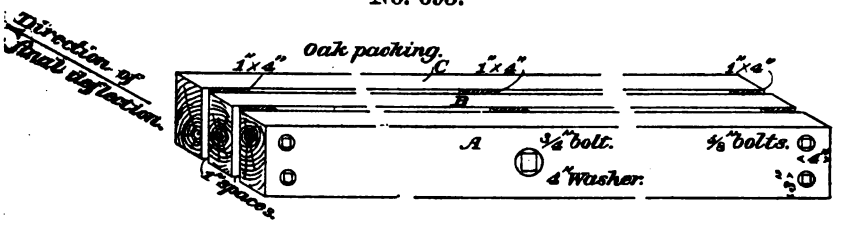
Failed by horizontal deflection, minus direction.

Deflections increased to 2".50 horizontal.

Stick B failed at the end notches in a similar manner to sketches showing failure of post No. 661.

Stick A crushed fibers at a knot $1\frac{3}{4}$" diameter, 15" from south end.

No. 693.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	242	11	179.97	4.50	11.61	52.2	150
B	276	15	179.97	4.50	11.56	63.6	150
C	256	23	179.97	4.49	11.62	52.2	150
	774	.....	.....	.....	.....	168.0	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,100	500	.0320	.0002	0.05	0.
B	31,800	500	.0325	0.	.10	.01
C	26,100	500	.0148	—.0005	.01	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.01	—.02	.....	
40,000	.01	—.03	.....	
80,000	.01	—.03	.....	
100,000	.01	—.03	.10	
140,000	.01	—.03	.....	
180,000	.01	—.03	.....	
200,000	.02	—.03	.14	
240,000	.02	—.03	.....	
280,000	.02	—.03	.....	
300,000	.03	—.04	.15	
340,000	.05	—.04	.....	
380,000	.06	—.04	.....	
400,000	.07	—.05	.....	
440,000	.09	—.05	.....	
480,000	.11	—.05	.....	
500,000	.16	—.05	.19	
520,000	.20	—.06	.....	
540,000	.28	—.06	.....	
560,000	.44	—.06	.....	
564,000	.90	—.06	.....	Ultimate strength = 3,357 pounds per square inch.

Failed by horizontal deflection, plus direction.

No. 694.

Same style of post as No. 693.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	198	17	180	4.50	11.35	51.1	150
B	290	24	180	5.59	11.36	63.5	150
C	208	10	180	4.46	11.35	50.6	150
	691	.....	.....	.....	.....	165.2	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,550	500	.0500	0.	.18	.01
B	31,750	500	.0650	.0003	.09	.02
C	25,300	500	.0610	.0005	0.	0.

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.04	0.	.....	
40,000	.04	0.	.....	
80,000	.05	.02	.....	
100,000	.05	.03	—.12	
140,000	.05	.04	.....	
180,000	.05	.05	.....	
200,000	.05	.05	—.13	
240,000	.05	.05	.....	
280,000	.04	.06	.....	
300,000	.04	.07	—.15	
340,000	.04	.07	.....	
380,000	.04	.08	.....	
400,000	.03	.09	—.15	
440,000	.01	.10	.....	
480,000	—.03	.10	.....	
500,000	—.10	.10	—.17	Ultimate strength = 3,027 per square inch.

Failed by deflecting horizontally, minus direction.

Horizontal deflection increased to —2″ without crushing fibers of wood or developing any local weakness.

No. 695.

Same style of post as No. 693.

Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	207	8	180	4.49	11.35	51.0	150
B	290	16	180	5.20	11.84	59.0	150
C	246	16	180	4.50	11.35	51.1	150
	743					161.1	

Stick.	Loads applied. Actual.	Loads applied. Pounds per square inch.	Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,500	500	.0429	.0002	—.01	0.
B	29,500	500	.0290	.0004	—.06	0.
C	25,550	500	.0410	.0001	0.	0.

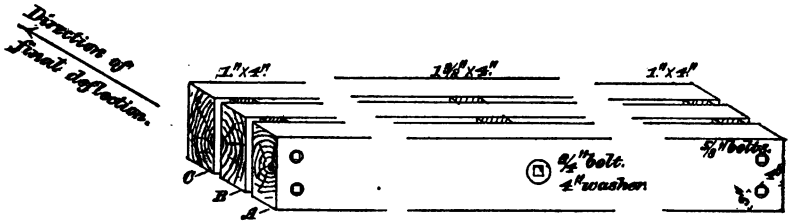
Test of the built post.

Loads applied.	Deflections. Horizontal.	Deflections. Vertical, W.	Deflections. Vertical, E.	Remarks.
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	Stick B, "shaky"; has longitudinal seams. Stick C has dull, dead appearance in places.
20,000	0.	.02		
40,000	0.	.02		
80,000	—.01	.02		
100,000	—.01	.02	.02	
140,000	—.01	.04		
180,000	—.01	.05		
200,000	—.01	.06	.02	
240,000	—.01	.07		
280,000	—.01	.10		
300,000	—.01	.10	.02	
340,000	—.01	.12		
360,000	—.01	.12		
380,000	—.01	.14		
400,000	—.03	.16	.04	
420,000	—.03	.18		
440,000	—.05	.19		
460,000	—.07	.20		
474,000				Ultimate strength = 2,942 pounds per square inch.

Stick B failed by opening longitudinal seams.

No. 696.

SWELLED POST.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	217	25	180	4.51	11.24	50.7	150
B	253	11	180	5.50	11.23	61.8	150
C	190	15	180	4.48	11.23	50.3	150
	660	.....	.....	.....	.....	162.8	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,350	500	.0337	0.	.08	.02
B	30,900	500	.0567	.0003	— .05	0.
C	25,150	500	.0715	.0010	.24	.03

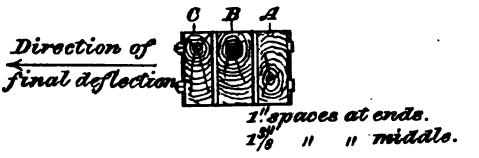
Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0	0.	0.	0.	
20,000	.02	0.	.....	
40,000	.02	0.	.....	
80,000	.05	.04	.....	
100,000	.05	.05	— .10	
140,000	.09	.09	.....	
180,000	.09	.10	.....	
200,000	.09	.10	— .10	
240,000	.09	.11	.....	
280,000	.09	.12	.....	
300,000	.09	.13	— .10	
340,000	.09	.14	.....	
380,000	.09	.16	.....	
400,000	.09	.16	— .15	
440,000	.10	.17	.....	
480,000	.30	.18	.....	Ultimate strength = 2,948 pounds per square inch.

Failed by horizontal deflection plus direction. Horizontal deflection increased to 2″ without developing any local weakness.

No. 697.

Same style of post as No. 696.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	242	15	180	4.52	11.60	52.4	150
B	249	12	180	5.43	11.60	63.0	150
C	215	15	180	4.47	11.58	51.8	150
	706	.....	.....	.....	.....	167.2	.....

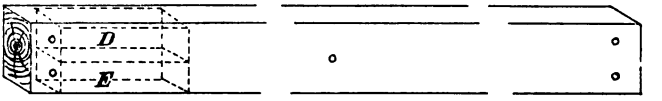
Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	26,200	500	.0240	0.	— .15	— .01
B	31,500	500	.0330	— .0007	— .01	0.
C	25,900	500	.0336	0.	.28	.02

Test of the built post.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0.	0.	0.	0.	North end of stick A shaky.
20,000	0.	.01	.....	
40,000	0.	.03	.....	
80,000	0.	.04	.....	
100,000	0.	.05	.05	
140,000	0.	.05	.....	
180,000	0.	.05	.....	
200,000	0.	.06	.08	
240,000	0.	.06	.....	
280,000	0.	.06	.....	
300,000	0.	.07	.....	
340,000	0.	.08	.....	
380,000	.01	.08	.....	
400,000	.02	.08	.11	
440,000	.04	.08	.....	
460,000	.07	.09	.....	
480,000	.09	.09	.....	
500,000	.12	.09	.....	
520,000	.19	.10	.....	
540,000	.50	.10	.....	Ultimate strength = 3,230 lbs. per square inch.

Failed by horizontal deflection, plus direction.

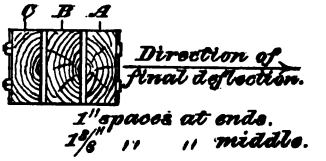
Test of specimens cut from No. 697, stick A.



Specimen.	Weight.	Rings per inch.	Length.	Size.	Sectional area.	Ultimate strength.		Remarks.
						Actual.	Pounds per square inch.	
	Lbs.		*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*		
D	7¼	6	19.95	5×3	15	73,000	4,867	Fibers crushed.
E	7	18	19.93	4.48×3	13.44	85,600	6,369	Do.

No. 698.

Same style of post as No. 696.



Preliminary test of the single sticks.

Stick.	Weight.	Rings per inch.	Total length.	Width.	Depth.	Sectional area.	Gauged length.
	Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*
A	224	15	179.94	4.46	11.60	51.7	150
B	255	8	179.94	5.53	11.70	64.7	150
C	296	15	179.94	4.50	11.59	52.2	150
	775	.....	.....	.....	.....	168.6	.....

Stick.	Loads applied.		Compression.	Compression set.	Horizontal deflection.	Permanent horizontal deflection.
	Actual.	Pounds per square inch.				
	Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*
A	25,850	500	.0290	.0009	—.34	—.02
B	32,350	500	.0585	.0005	.04	0.
C	26,100	500	.0341	.0004	.12	.02

Test of the built post.

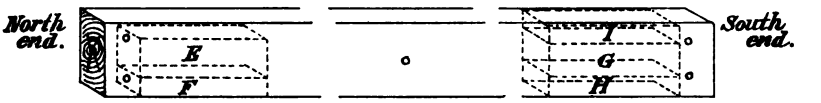
Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
0.	0.	0.	0.	
20,000	0.	.02	.....	
40,000	—.01	.04	.....	
80,000	—.01	.07	.....	

Test of the built post—Continued.

Loads applied.	Deflections.			Remarks.
	Horizontal.	Vertical, W.	Vertical, E.	
Pounds.	*Inch.*	*Inch.*	*Inch.*	
100,000	—.01	.08	—.04	
140,000	0.	.09	.....	
180,000	0.	.09	.....	
200,000	0.	.09	—.05	
240,000	0.	.09	.....	
280,000	0.	.09	.....	
300,000	0.	.09	—.07	
340,000	—.01	.09	.....	
380,000	—.02	.10	.....	
400,000	—.03	.10	.....	
440,000	—.06	.10	.....	
460,000	—.08	.10	.....	
480,000	—.12	.09	.....	
500,000	—.17	.09	—.10	
510,000	—.20	.09	.....	
520,000	—.26	.09	.....	
530,000	—.33	.09	.....	
540,000	—.48	.08	.....	
544,000	—.75	.....	.....	Ultimate strength = 3,227 lbs. per square inch.

Failed by horizontal deflection, minus direction.
Horizontal deflection increased to 2″.
Sticks taking uniform bend without crushing fibers locally.

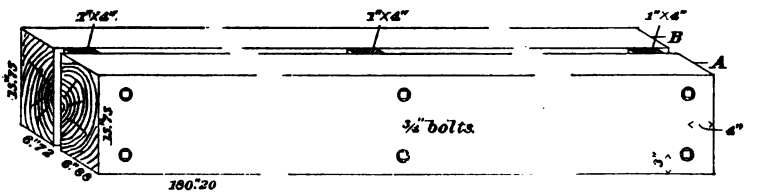
Test of specimens cut from No. 698, stick C.



South end of stick as placed in testing machine very resinous.
The rate of growth was most rapid near the heart of the stick.
Specimens E and G have about the same rate of growth, containing the heart; specimens F and H having about the same rate of growth.

Specimen.	Weight.	Rings per inch.	Length.	Size.	Sectional area.	Ultimate strength.		Remarks.
						Actual.	Pounds per square inch.	
	Lbs.		*In.*	*Inches.*	*Sq. in.*	*Pounds.*		
E	11	11	20	5.02x4.50	22.59	123,500	5,467	Fibers crushed.
F	6½	22	20	3 x4.50	13.50	86,500	6,407	Do.
G	15½	11	20	5.02x4.50	22.59	123,800	5,480	Do.
H	11	20	20	3 x4.50	13.50	79,200	5,866	Do.
I	8½	20	20	2.75x4.48	12.32	81,800	6,640	Do.

No. 488.



Weight (posts, packing, and bolts), 911 pounds.
Sectional area, 108.36; 105.84 = 214.2 square inches.

Gauged length taken on post A, 160″.
Post free from knots.
Stick A, new timber, has not been previously tested.
Stick B previously tested in built post No. 691.

Loads applied.	Pounds per square inch.	Compression.	Permanent set.	Deflections.		Remarks.
				Horizontal.	Vertical.	
Pounds.		*Inch.*	*Inch.*	*Inch.*	*Inch.*	
10,000	.....	0.	.....	0.	0.	
50,000	.....	.0148	.....	0.	0.	
10,000	.....	.....	0.	0.	0.	
100,000	.....	.0355	.....	0.	0.	
10,000	.....	.....	0.	0.	0.	
150,000	.....	.0560	.....	0.	0.	
10,000	.....	.....	0.	0.	0.	
200,000	.....	.0785	.....	−.02	0.	
10,000	.....	.....	.0010	0.	0.	
250,000	.....	.1008	.....	−.05	0.	
10,000	.....	.....	.0010	0.	0.	Snapping sounds heard.
300,000	.....	.1240	.....	−.08	0.	
10,000	.....	.....	.0015	0.	0.	
350,000	.....	.1480	.....	−.10	0.	
10,000	.....	.....	.0021	−.01	0.	
400,000	.....	.1730	.....	−.13	0.	
10,000	.....	.....	.0030	−.02	0.	
450,000	.....	.....	.....	−.17	.02	
500,000	.....	.....	.....	−.20	.05	
550,000	.....	.....	.....	−.28	.06	
600,000	.....	.....	.....	−.34	.06	
650,000	.....	.....	.....	−.45	.06	
700,000	3,268	.....	.....	−.75	.06	Ultimate strength.
.....	.....	.....	.....	−1.50	.06	Deflections after sustaining load 6 minutes.
10,000	.....	.....	.....	−.40	0.	

Longitudinal cracks opened along middle of stick B; no cracks developed in stick A.
Time of test, one hour.

Compression of yellow-pine posts.

TABULATED RESULTS.

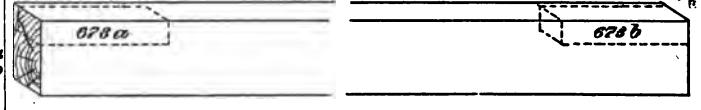
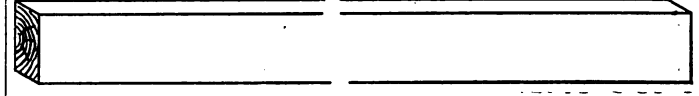
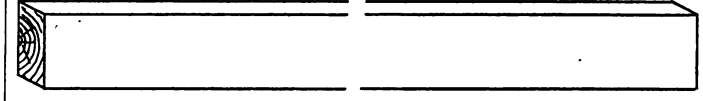
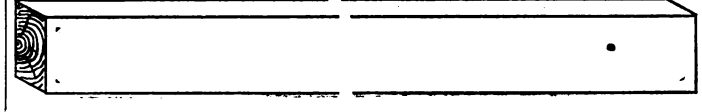
Number of test.	Weight.	Average rate of growth, rings per inch.	Size of post.			Sectional area.	Ultimate strength.		Manner of failure.
			Length.	Width.	Depth.		Actual.	Pounds per square inch.	
	Lbs.		*Ft. In.*	*In.*	*In.*	*Sq. in.*	*Pounds.*		
565	47	20	5 .06	5.50	5.50	30.3	172,000	5,677	Fibers crushed 12″ from end of post.
566	44	12	5 .10	5.50	5.49	30.2	141,000	4,669	Failed at knots 15″ from end.
567	45	25	5 .10	5.48	5.54	30.4	168,000	5,526	Failed at knots 9″ and 17″ from end of post.
568	47½	20	5 .10	5.46	5.50	30	108,000	3,600	Failed at knot 8″ from end of post.
562	72½	.....	7 5.98	5.45	5.52	30.1	140,000	4,651	Failed at season-cracks; crushed fibers.
563	59½	.....	7 6.14	5.46	5.46	29.8	124,000	4,161	Failed at knots 30″ from end of post.
564	57	.....	7 6.15	5.47	5.47	29.9	143,500	4,799	Failed at knots 27″ from end of post.
559	86	.....	10 .17	5.49	5.48	30.1	146,200	4,857	Deflected upward.
560	88½	.....	10 .16	5.50	5.47	30.1	139,000	4,618	Deflected downward.
561	110	.....	10 .15	5.51	5.50	30.3	143,600	4,739	Failed at knots middle of post.
556	126	.....	12 6.12	5.54	5.51	30.5	156,000	5,114	Deflected horizontally.
557	128	.....	12 6.17	5.47	5.52	30.2	156,000	5,166	Deflected diagonally.
558	141½	.....	12 6.20	5.50	5.50	30.3	150,000	4,950	Do.

Compression of yellow-pine posts—Continued.

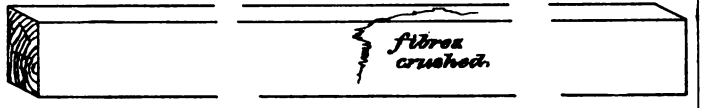
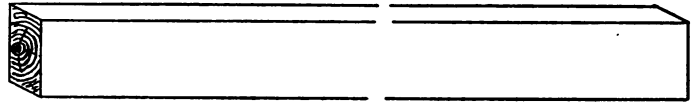
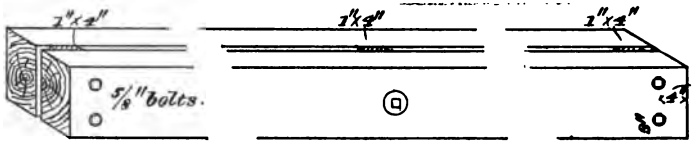
Number of test.	Weight.	Average rate of growth, rings per inch.	Size of post.			Sectional area.	Ultimate strength.		Manner of failure.
			Length.	Width.	Depth.		Actual.	Pounds per square inch.	
	Lbs.		*Ft. In.*	*In.*	*In.*	*Sq. in.*	*Pounds.*		
553	140	.....	15 .22	5.50	5.48	30.1	99,200	3,296	Deflected downward.
554	148	.....	15 .24	5.49	5.47	30	130,000	4,333	Deflected horizontally.
555	148	.....	15 .25	5.50	5.50	30.3	129,000	4,257	Deflected diagonally.
550	172	.....	17 6.24	5.48	5.47	30	90,000	3,000	Deflected horizontally.
551	180½	.....	17 6.25	5.46	5.46	29.8	109,000	3,658	Do.
552	167½	.....	17 6.26	5.50	5.50	30.3	93,000	3,069	Do.
548	185	.....	20 .30	5.40	5.45	29.4	82,000	2,789	Do.
549	185	.....	20 .28	5.45	5.46	29.8	87,800	2,946	Do.
545	212	.....	22 6.28	5.64	5.59	31.5	73,700	2,340	Do.
546	189	.....	22 6.37	5.42	5.49	29.8	56,000	1,879	Deflected upward.
547	266	.....	22 6.30	5.65	5.61	31.7	62,500	1,972	Deflected diagonally.
508	210	.....	25 .36	5.46	5.48	29.9	52,000	1,739	Deflected horizontally.
509	235	.....	25 .30	5.46	5.49	30	59,000	1,967	Do.
510	210	.....	25 .33	5.45	5.46	29.8	55,500	1,862	Do.
499	258	.....	27 6.44	5.31	5.29	28.1	60,800	2,163	Do.
500	236	.....	27 6.43	5.32	5.30	28.2	39,000	1,383	Deflected diagonally.
501	256	.....	27 6.40	5.31	5.30	28.1	44,400	1,580	Deflected horizontally.
572	124	6	6 8.10	7.78	9.75	75.8	260,000	3,430	Failed at a knot 30″ from end of post.
573	131	14	6 8.08	7.76	9.77	75.8	286,500	3,780	Failed at a knot 26″ from end of post.
574	161½	21	6 8.10	7.74	9.81	75.9	383,000	5,046	Failed at knots 8″ from end of post.
578	233½	23	10 .13	7.74	9.73	75.3	304,000	4,037	Failed at a knot 18″ from end of post.
579	240	19	10 .14	7.78	9.75	75.9	399,500	5,264	Failed 36″ from end; grain of wood wavy.
580	240	28	10 .14	7.75	9.75	75.6	350,000	4,629	Failed at knot 17″ from end of post.
584	266	18	13 4.18	7.68	9.72	74.6	307,500	4,122	Failed at knots 15″ and 29″ from end of post.
585	258	6	13 4.15	7.75	9.74	75.5	284,000	3,762	Failed at knots 45″ from end of post.
586	336	23	13 4.20	7.75	9.75	75.6	296,000	3,921	Failed at knots near middle of post.
587	318	24	16 8.17	7.70	9.74	75	274,500	3,660	Failed at knots 50″ from end of post.
588	381	12	16 8.24	7.74	9.73	75.3	382,000	5,073	Deflected horizontally.
589	339½	21	16 8.26	7.25	9.49	68.8	304,000	4,419	Do.
530	461	.....	20 .25	7.71	9.80	75.6	287,000	3,796	Do.
531	410	.....	20 .28	7.76	9.58	74.3	275,000	3,701	Failed at knots 70″ from end of post.
532	391	.....	20 .25	7.61	9.68	73.7	220,000	2,985	Deflected horizontally.
542	501	.....	23 4.20	7.69	9.77	75.1	225,000	2,996	Do.
543	501	.....	23 4.20	7.69	9.73	74.8	220,500	2,948	Do.
544	560	.....	23 4.22	7.70	9.76	75.1	298,000	3,968	Do.
527	531	.....	26 8.30	7.40	9.47	70	210,000	3,000	Do.
528	627	.....	26 8.29	7.45	9.45	70.4	205,000	2,912	Do.
529	535	.....	26 8.30	7.46	8.94	66.7	184,500	2,766	Deflected diagonally.
711	375	12	15 .08	5.60	15.60	87.4	349,000	3,993	Deflected horizontally.
712	397	21	15 .05	5.63	15.57	87.7	339,000	3,865	Do.
713	382	15	15 .00	5.65	15.50	87.6	272,500	3,111	Do.
484	432	.....	15 .25	6.90	15.85	109.4	270,000	2,468	Deflected horizontally; knot on concave side.
708	464	17	15 .00	6.61	15.51	102.5	340,000	3,317	Failed at some knots at middle of post.
709	557	18	15 .00	6.60	15.64	103.2	455,000	4,400	Deflected horizontally.
710	491	18	14 11.92	6.61	15.61	103.2	432,000	4,186	Do.
641	561	5	15 .10	8.25	16.25	134	428,000	3,194	Fibers crushed at middle of post, vicinity of knots.
671	585	12	15 .07	8.25	16.20	133.6	425,000	3,181	Deflected horizontally.
672	578	13	14 11.93	8.20	16.20	132.8	526,000	3,961	Do.
485	434	.....	15 .27	6.75	15.95	107.7	175,000	1,625	Deflected horizontally; knots on concave side. (Second test of these posts.)
487	450	.....	15 .25	6.80	15.72	106.9	310,000	2,900	Deflected horizontally; initial bend in post. (Second test of these posts.)
486	705	.....	15 .24	8.63	16.83	145.2	380,000	2,617	Opened shakes and season-cracks. (Second test of these posts.)

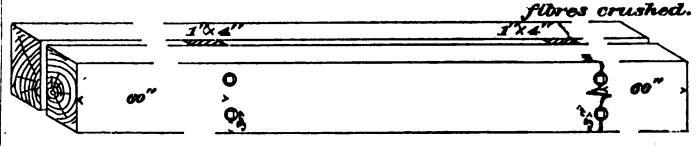
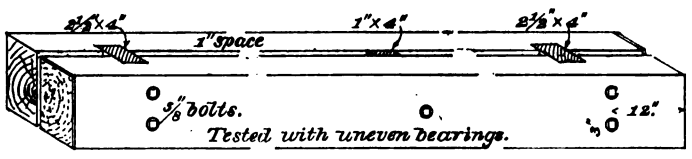
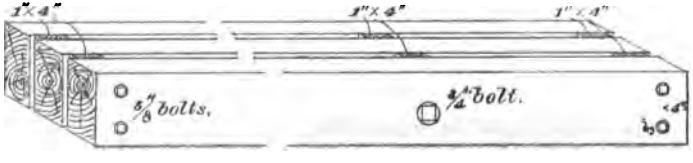
Compression of yellow pine—Single sticks and built posts.

TABULATED RESULTS.

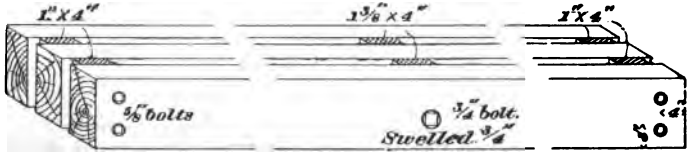
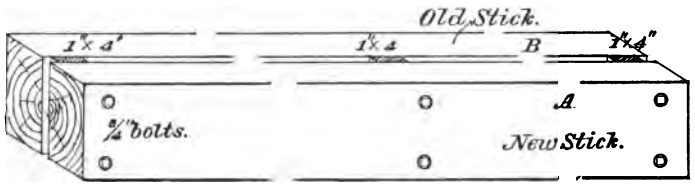
Number of test.	Kind of post.	Weight.	Average rate of growth. Rings per inch.	Dimensions of post. Length.	Width.	Depth.	Sectional area.	Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength. Actual.	Pounds per square inch.
		Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inch.*	*Pounds.*	
673		260	11	180.05	4.09	11.35	46.04	.0370	142,200	3,065
673a		13		20	4.01	4.01	16.08		94,000	5,846
673b		7½		20	3.95	3.97	15.68		99,600	6,352
674		233	17	180	4.51	11.60	52.3	.0492	131,500	2,515
675		194	22	180	4.34	11.60	50.3	.0490	121,200	2,410
490		269	.....	180	5.05	12.10	61.1	.....	230,000	3,764

Compression of yellow pine—single sticks and built posts—Continued.

Number of test.	Kind of post.	Weight.	Average rate of growth. Rings per inch.	Dimensions of post. Length.	Width.	Depth.	Sectional area.	Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength. Actual.	Pounds per square inch.
		Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inch.*	*Pounds.*	
670		309	12	180	5.65	11.74	66.3	.0455	205,900	3,106
489		287	.....	180.08	5.85	12.05	70.5	.....	250,000	3,546
654		326 / 290 } 616	11 / 6	180 / 180	5.63 / 5.62	11.71 / 11.71	65.9 / 65.9 } 131.8	.0418 / .0540	470,000	3,566
655	Same style as No. 654	292 / 329 } 621	34 / 24	179.93 / 179.93	5.64 / 5.63	11.72 / 11.72	66.1 / 66.1 } 132.2	.0292 / .0315	580,000	4,387
656	Same style as No. 654	282 / 287 } 569	13 / 11	180 / 180	5.61 / 5.61	11.71 / 11.71	65.7 / 65.7 } 131.4	.0368 / .0466	480,000	3,653

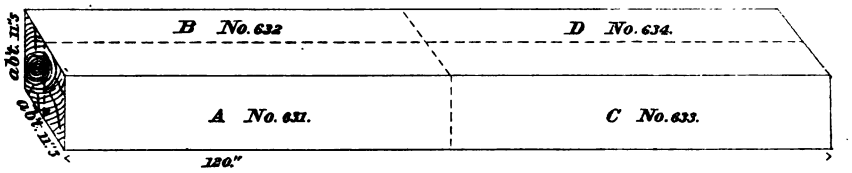
651	Same as No. 654, except swelled ¾″ at middle	262 275	537	11 7	180 180	5.58 5.58	11.71 11.71	65.3 65.3	130.6	.0620 .0514	360,000	2,756
652	Same as No. 654, except swelled ¾″ at middle	310 370	680	16 16	180 180	5.58 5.58	11.70 11.71	65.3 65.3	130.6	.0395 .0360	588,500	4,506
653	Same as No. 654, except swelled ¾″ at middle	310 311	621	16 12	180 180	5.63 5.59	11.71 11.68	65.9 65.3	131.2	.0559 .0550	436,600	3,328
657		340 319	659	9 13	179.96 179.96	5.63 5.64	11.72 11.71	66.0 66.0	132.0	.0375 .0305	580,000	4,394
658	Same style as No. 657	319 332	651	12 9	179.98 179.98	5.59 5.59	11.71 11.72	65.5 65.5	131.0	.0320 .0436	448,000	3,420
659	Same style as No. 657	320 293	613	12 8	180 180	5.61 5.61	11.73 11.73	65.8 65.8	131.6	.0312 .0372	600,000	4,559
660		283 294	577	25 18	180.03 180.03	5.61 5.63	11.22 11.24	62.9 63.3	126.2	.0325 .0400	510,000	4,041
661	Same style as No. 660. Tested with uneven bearings	274 310	584	12 9	180 180	5.66 5.60	11.70 11.72	66.2 65.6	131.8	.0410 .0365	410,000	3,111
662	Same style as No. 660. Tested with uneven bearings	292 280	572	14 8	180 180	5.61 5.61	11.75 11.75	65.9 65.9	131.8	.0340 .0500	388,000	2,944
693		242 276 256	774	11 15 23	179.97 179.97 179.97	4.50 5.50 4.49	11.61 11.56 11.62	52.2 63.6 52.2	168.0	.0320 .0325 .0148	564,000	3,357

Compression of yellow pine—single sticks and built posts—Continued.

Number of test.	Kind of post.	Weight.	Average rate of growth. Rings per inch.	Dimensions of post. Length.	Width.	Depth.	Sectional area.	Compression in 150 inches. Load of 500 pounds per square inch.	Ultimate strength. Actual.	Pounds per square inch.
		Pounds.		*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Inch.*	*Pounds.*	
694	Same style as No. 693	193 290 } 691 208	17 24 } 15 10	180 180 180	4.50 5.59 4.46	11.35 11.36 11.35	51.1 63.5 } 165.2 50.6	.0500 .0650 } 500,000 .0610		3,027
695	Same style as No. 693	207 290 } 743 246	8 16 } 16 16	180 180 180	4.49 5.20 4.50	11.35 11.34 11.35	51.0 59.0 } 161.1 51.1	.0429 .0290 } 474,000 .0410		2,942
696		217 253 } 660 190	25 11 } 15 15	180 180 180	4.51 5.50 4.48	11.24 11.23 11.23	50.7 61.8 } 162.8 50.3	.0337 .0567 } 480,000 .0715		2,948
697	Same style as No. 696	242 249 } 706 215	15 12 } 15 15	180 180 180	4.52 5.43 4.47	11.60 11.60 11.58	52.4 63.0 } 167.2 51.8	.0240 .0330 } 540,000 .0336		3,230

698	Same style as No. 696	224 255 296	775	15 8 15	179.94 179.94 179.94	4.46 5.53 4.50	11.60 11.70 11.59	51.7 64.7 52.2	168.6	.0290 .0585 .0341	544,000	3,227
488		911		.....	180.20	6.88 6.72	15.75 15.75	108.36 105.84	214.2	.....	700,000	3,268

THOROUGHLY SEASONED YELLOW-PINE POST FROM THE ARSENAL STOREHOUSE.

TIME TESTS.



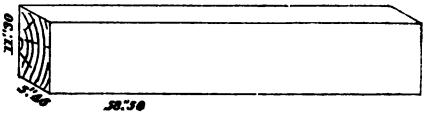
Yellow-pine post about 11″.5 square by 10 feet long, cut into four specimens—A, B, C, and D.

Specimens A and D tested by gradually increasing the compression loads till failure took place.

Specimens B and C tested by applying increments of 200 pounds per square inch compression, allowing each increment to remain five minutes; measuring the compression when first applied and again at the end of five minutes, then releasing the strains to zero-load, measuring the compression set immediately and again after five minutes' rest; so proceeding to the end of the test.

No. 631.

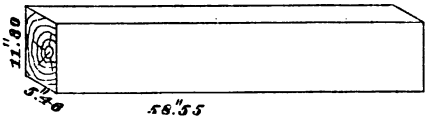
SPECIMEN A.



Sectional area, 61.7 square inches.
Weight, 86½ pounds.
Average rate of growth, 9 rings per inch.
Ultimate strength, 422,000 pounds = 6,840 pounds per square inch.
Time of test, 14 minutes.
Deflected sideways, crushing fibers on the concave side.

No. 632.

SPECIMEN B.



Sectional area, 61.7 square inches.
Weight, 85 pounds.
Gauged length, 30″.

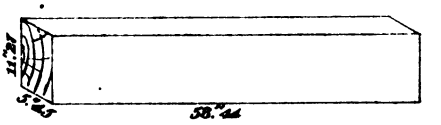
Loads applied.	Pounds per square inch.	Compression	Compression set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
0	0	0.		
12,340	200	0.		
		0.		
	0		— .0005	
			— .0005	
24,680	400	.0022		
		.0024		
	0		— .0008	
			— .0006	
37,020	600	.0050		
		.0052		
	0		— .0006	
			— .0008	
49,360	800	.0078		
		.0079		
	0		—. 0006	
			—. 0006	
61,700	1,000	.0108		
		.0110		
	0		— .0004	
			— .0008	
74,040	1,200	.0137		
		.0139		
	0		— .0005	
			— .0008	
86,380	1,400	.0164		
		.0166		
	0		— .0006	
			— .0008	
98,720	1,600	.0191		
		.0194		
	0		— .0005	
			— .0005	
111,060	1,800	.0219		
		.0221		
	0		— .0004.	
			— .0005	
123,400	2,000	.0248		
		.0249		
	0		— .0002	
			— .0003	
			0.	Rested over night 15 hours.
135,740	2,200	.0270		
		.0275		
	0		0.	
			0.	
148,080	2,400	.0300		
		.0301		
	0		.0003	
			.0002	
160,420	2,600	.0326		
		.0330		
	0		.0005	
			.0005	
172,760	2,800	.0358		
		.0360		
	0		.0009	
			.0005	
185,100	3,000	.0388		
		.0398		
	0		.0010	
			.0009	
197,440	3,200	.0420		
		.0424		
	0		.0011	
			.0010	
209,780	3,400	.0449		
		.0453		
	0		.0015	
			.0011	
222,120	3,600	.0478		
		.0483		
	0		.0019	
			.0015	
234,460	3,800	.0509		
		.0513		
	0		.0018	
			.0016	
246,800	4,000	.0539		
		.0546		

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
	0		.0024	
			.0020	
259,140	4,200	.0570		
		.0576		
	0		.0025	
			.0020	
271,480	4,400	.0600		
		.0607		
	0		.0030	
			.0025	
283,820	4,600	.0634		
		.0646		
	0		.0035	
			.0030	
296,160	4,800	.0670		
		.0682		
	0		.0044	
			.0035	
308,500	5,000	.0702		
		.0720		
	0		.0050	
			.0042	
320,840	5,200	.0742		
		.0762		
	0		.0060	
			.0052	
333,180	5,400	.0785		
		.0810		
	0		.0075	
			.0063	
345,520	5,600	.0830		
		.0870		
	0		.0089	
			.0080	
357,860	5,800	.0891		
		.0941		
	0		.0114	
			.0097	
370,200	6,000	.0965		
		.1008		
	0		.0133	
			.0115	
382,540	6,200	.1030		Ultimate strength.

Crushed fibers 12″ from end at a knot.

No. 633.

SPECIMEN C.



Sectional area, 61.4 square inches.
Weight, 86 pounds.
Gauged length, 30″.

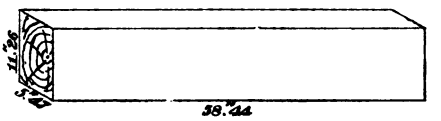
Loads applied.	Pounds per square inch.	Compression.	Compression set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
0	0	0.		
12,280	200	.0024		
		.0024		
	0		.0006	
			.0008	
24,560	400	.0052		
		.0052		
	0		.0007	
			.0005	
36,840	600	.0079		
		.0080		
	0		.0009	
			.0005	
49,120	800	.0106		
		.0112		
	0		.0008	
			.0005	
61,400	1,000	.0139		
		.0140		
	0		.0006	
			.0006	
73,680	1,200	.0169		
		.0171		
	0		.0009	
			.0010	
85,960	1,400	.0197		
		.0199		
	0		.0010	
			.0009	
98,240	1,600	.0227		
		.0230		
	0		.0011	
			.0010	
110,520	1,800	.0258		
		.0259		
	0		.0013	
			.0010	
122,800	2,000	.0284		
		.0289		
	0		.0011	
			.0010	
135,080	2,200	.0315		
		.0318		
	0		.0013	
			.0010	
147,360	2,400	.0347		
		.0350		
	0		.0015	
			.0011	Rested 30 minutes without further recovery.
159,640	2,600	.0377		
		.0381		
	0		.0018	
			.0015	
171,920	2,800	.0410		
		.0410		
	0		.0020	
			.0016	
184,200	3,000	.0440		
		.0445		

Loads applied.	Pounds per square inch.	Compression.	Compression set.	Remarks.
Pounds.		*Inch.*	*Inch.*	
	0		.0020	
			.0020	
196,480	3,200	.0470		
		.0477		
	0		.0025	
			.0020	
208,760	3,400	.0500		
		.0505		
	0		.0030	
			.0021	
221,040	3,600	.0535		
		.0540		
	0		.0030	
			.0029	
233,320	3,800	.0564		
		.0572		
	0		.0037	
			.0030	
245,600	4,000	.0599		
		.0610		
	0		.0040	
			.0036	
257,880	4,200	.0634		
		.0640		
	0		.0044	
			.0040	
270,160	4,400	.0664		
		.0675		
	0		.0050	Rested over night 15 hours.
			.0043	
			.0032	
282,440	4,600	.0691		
		.0707		
	0		.0053	
			.0049	
294,720	4,800	.0730		
		.0739		
	0		.0063	
			.0052	
307,000	5,000	.0764		
		.0780		
	0		.0070	
			.0062	
319,280	5,200	.0810		
		.0825		
	0		.0080	
			.0070	
331,560	5,400	.0850		
		.0875		
	0		.0095	
			.0085	
343,840	5,600	.0898		
		.0931		
	0		.0115	
			.0101	
356,120	5,800	.0958		
		.0995		
	0		.0138	
			.0121	
368,400	6,000	.1025		
		.1074		
	0		.0167	
			.0149	
380,680	6,200	.1125		
		.1194		
	0		.0210	
			.0192	
392,960	6,400	.1234		
		.1335		
	0		.0280	
			.0250	
405,240	6,600	.1357		Ultimate strength.

Fibers crushed 16″ from end of specimen, which took a slight deflection sideways.

No. 634.

SPECIMEN D.



Sectional area, 61. 6 square inches.
Weight, 88½ pounds.
Gauged length, 30″.

Loads applied.	Pounds per square inch.	Compression.	Remarks.
Pounds.		*Inch.*	
0	0	0.	
12, 320	200	.0040	
24, 640	400	.0075	
36, 960	600	.0108	
49, 280	800	.0134	
61, 600	1, 000	.0159	
73, 920	1, 200	.0185	
86, 240	1, 400	.0214	
98, 560	1, 600	.0240	
110, 880	1, 800	.0268	
123, 200	2, 000	.0292	
135, 520	2, 200	.0320	
147, 840	2, 400	.0348	
160, 160	2, 600	.0375	
172, 480	2, 800	.0404	
184, 800	3, 000	.0430	
197, 120	3, 200	.0460	
209, 440	3, 400	.0485	
221, 760	3, 600	.0512	
234, 080	3, 800	.0540	
246, 400	4, 000	.0570	
258, 720	4, 200	.0598	
271, 040	4, 400	.0627	
283, 360	4, 600	.0655	
295, 680	4, 800	.0682	
308, 000	5, 000	.0712	
320, 320	5, 200	.0744	
332, 640	5, 400	.0776	
344, 960	5, 600	.0812	
357, 280	5, 800	.0852	
369, 600	6, 000	.0892	
381, 920	6, 200	.0938	
394, 240	6, 400	.0975	
428, 700	.....	.....	Ultimate strength.

Time of test, 22 minutes.
Fibers crushed from 4″ to 8″ from end of specimen.

COMPRESSION OF WOOD (OAK AND PINE).

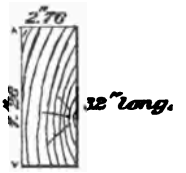
Compression tests of samples of yellow pine and white oak cut from round posts tested for Edward Atkinson.

Specimens rectangular, 32″ long each.

WHITE OAK.

Dimensions of original post: Length, 168″; diameter, 10″.54; sectional area, 84.8 square inches; diameter of core, 1″.75.
Ultimate strength, 420,000 pounds = 4,953 pounds per square inch.

No. 621.

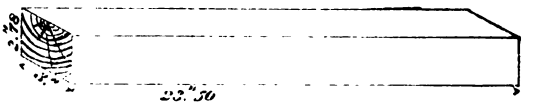


Sectional area, 20 square inches.
Weight, 17¼ pounds.
Ultimate strength, 169,000 pounds = 8,450 pounds per square inch.
Failed 6″ from end where the grain was wavy.

No. 621*a*.

WHITE OAK.

Specimen cut from No. 621.



Sectional area, 8.34 square inches.
Ultimate strength, 65,000 pounds = 7,794 pounds per square inch.
Failed at a knot 5″ from end.

No. 622.

Specimen cut from same post as No. 621.

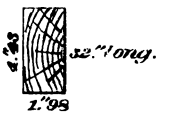
Sectional area, 20 square inches.
Weight, 17½ pounds.
Ultimate strength, 137,000 pounds = 6,850 pounds per square inch.
Failed by opening a longitudinal seam along a row of knots.

YELLOW PINE.

Dimensions of original post: Length, 167″.90; diameter, 7″.70; sectional area (mean), 45.8 square inches; diameter of core, 1″.60.

Ultimate strength, 200,000 pounds = 4,367 pounds per square inch.

No. 623.

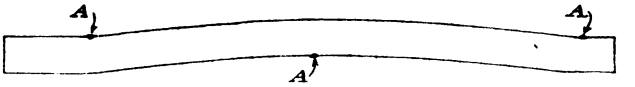


Sectional area, 8.77 square inches.

Weight, 8 pounds.

Ultimate strength, 47,300 pounds = 5,390 pounds per square inch.

Failed by deflecting sideways, crushing fibers on the concave side at middle; also $1\frac{3}{4}$″ from one end and $4\frac{3}{4}$″ from the other end on the opposite side from the crushing at the middle, as indicated by letters *A* on the sketch.



No. 624.

Specimen cut from same post as No. 623.

Sectional area, 8.8 square inches.

Weight, 9 pounds.

Ultimate strength, 48,300 pounds = 5,490 pounds per square inch.

Failed by deflecting sideways, crushing fibers on the concave side.

YELLOW PINE.

Original post tested with one flat end and one round end.

Dimensions of original post: Length, 143″.04; diameter, 8″; sectional area, 48.25 square inches; diameter of core, 1″.60.

Ultimate strength, 225,000 pounds = 4,663 pounds per square inch.

No. 625.

Sectional area, 8.8 square inches.

Weight, 8 pounds.

Ultimate strength, 51,200 pounds = 5,820 pounds per square inch.

Failed by fibers crushing, stick taking a slight horizontal deflection.

No. 626.

Specimen cut from same post as No. 625.

Sectional area, 8.8 square inches.
Weight, 8 pounds.
Ultimate strength, 58,000 pounds = 6,590 pounds per square inch.
Fibers crushed at a knot 9″ from end of specimen.

WHITE OAK.

Dimensions of original post: Length, 164″.08; diameter, 9″.25; sectional area, 64.4 square inches; diameter of core, 1″.90.
Ultimate strength, 221,000 pounds = 3,432 pounds per square inch.

No. 627.

Sectional area, 13.1 square inches.
Weight, 11½ pounds.
Ultimate strength, 63,100 pounds = 4,817 pounds per square inch.
Failed at a knot 10″ from end of specimen.

No. 628.

Specimen cut from same post as No. 627.

Sectional area, 13 square inches.
Weight, 11½ pounds.
Ultimate strength, 81,000 pounds = 6,230 pounds per square inch.
Failed at a group of knots 8″ from end of specimen.

WHITE OAK.

Tested with pintle ends.
Dimensions of original post: Length, 163″.80; diameter, 9″.35; sectional area, 65.8 square inches; diameter of core, 1″.90.
Ultimate strength, 215,000 pounds = 3,267 pounds per square inch.

No. 629.

Sectional area, 13.19 square inches.
Weight, 11¾ pounds.
Ultimate strength, 79,900 pounds = 6,058 pounds per square inch.
Failed at a group of knots near middle of specimen.

No. 630.

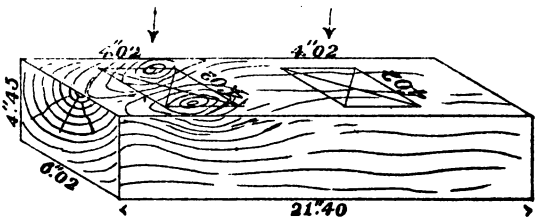
Specimen cut from same post as No. 629.

Sectional area, 13.08 square inches.
Weight, 11¾ pounds.
Ultimate strength, 80,900 pounds = 6,185 pounds per square inch.
Failed at a knot 6″ from end of specimen.

Indentation of wood perpendicular to grain.

No. 714.

WHITE PINE.



Compressed area, 4″.02×4″.02 = 16.16 square inches.
End A straight-grained.
End B compressed area covers two knots.
Cast-iron block pressed against wood.

END A.

Loads applied.	Pounds per square inch.	Indentation.	Remarks.
Pounds.		*Inch.*	
0	0	0.	
1,616	100	0.	
3,232	200	0.	
4,848	300	0.	
6,464	400	.01	
8,080	500	.02½	
9,696	600	.05	$\frac{1}{20}$″ indentation.
11,312	700	.46	

END B.

0	0	0.	
1,616	100	0.	
3,232	200	0.	
4,848	300	.01½	
6,464	400	.03	
8,080	500	.03½	
9,697	600	.03½	
11,312	700	.04	
12,300	.....	.05	$\frac{1}{20}$″ indentation.
12,928	800	.09	
14,544	900	.15	

No. 715.

WHITE PINE.

Size of specimen, $6'' \times 4''.4 \times 24''$ long.
Compressed area, $4''.02 \times 4''.02 = 16.16$ square inches.
End A straight-grained.
End B compressed area covers knot $1\frac{3}{4}''$ diameter.

END A.

Loads applied.	Pounds per square inch.	Indentation.	Remarks.
Pounds.		*Inch.*	
0	0	0.	
1,616	100	.01	
3,232	200	.02	
4,848	300	.02	
6,464	400	.03	
7,800	.....	.05	$\frac{1}{20}''$ indentation.
8,080	500	.08	
9,696	600	.28	

END B.

0	0	0.	
1,616	100	0.	
3,232	200	0.	
4,848	300	0.	
6,464	400	0.	
8,080	500	.01	
9,696	600	.01	
11,312	700	.01	
12,928	800	.02	
14,544	900	.02$\frac{1}{2}$	
16,160	1,000	.03	
19,100	.....	.05	$\frac{1}{20}''$ indentation.

No. 716.

WHITE PINE.

Size of specimen, $6'' \times 4''.4 \times 24''$ long.
Compressed area, $4''.02 \times 4''.02 = 16.16$ square inches.
End A straight-grained.
End B compressed area covers a knot $2\frac{1}{4}''$ diameter.

END A.

Loads applied.	Pounds per square inch.	Indentation.	Remarks.
Pounds.		*Inch.*	
0	0	0.	
1,616	100	0.	
3,232	200	0.	
4,848	300	.01	
6,464	400	.02	
8,080	500	.04	
9,696	600	.05	$\frac{1}{20}''$ indentation.
11,312	700	.14	
12,928	800	.31	

END B.

0	0	0.	
1,616	100	.00½	
3,232	200	.00½	
4,848	300	.00½	
6,464	400	.00½	
8,080	500	.01	
9,696	600	.01	
11,312	700	.02	
12,928	800	.02	
14,544	900	.02½	
16,160	1 000	.03	
23,400	.....	.05	1/16" indentation.
25,856	1,600	.13	

No. 717.

YELLOW PINE.

Size of specimen, 5".50 × 4".50 × 24".
Compressed area, 4".02 × 4".02 = 16.16 square inches.
End A straight-grained.
End B compressed area covers a knot 2¼" diameter.

END A.

Loads applied.	Pounds per square inch.	Indentation.	Remarks.
Pounds.		*Inch.*	
0	0	0.	
3,232	200	0.	
6,464	400	0.	
9,696	600	0.	
12,928	800	.00½	
16,160	1,000	.00½	
19,392	1,200	.03	
21,080	1,300	.03½	
22,624	1,400	.04½	
		.05	1/16" indentation.
24,240	1,500	.13	
25,856	1,600	.18	

END B.

0	0	0.	
3,232	200	.00½	
9,696	600	.00½	
16,160	1,000	.00½	
22,624	1,400	.01	
29,088	1,800	.02	
39,100	.....	.05	1/16" indentation.

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